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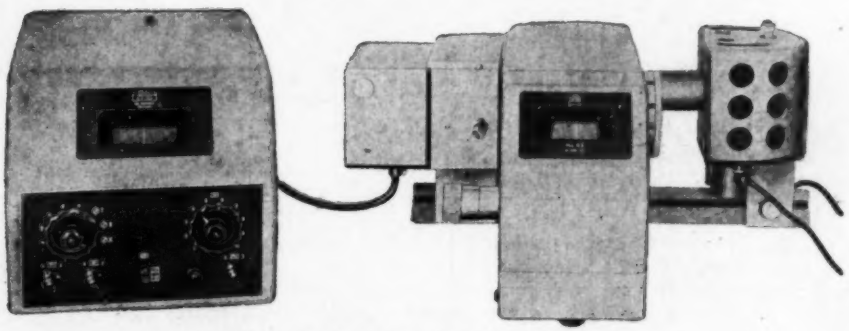

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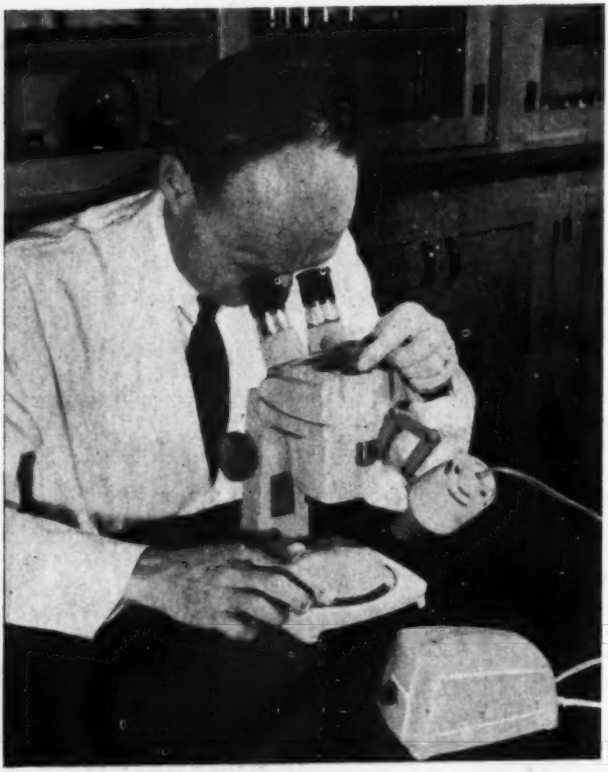

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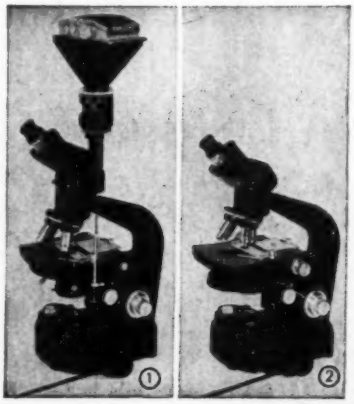

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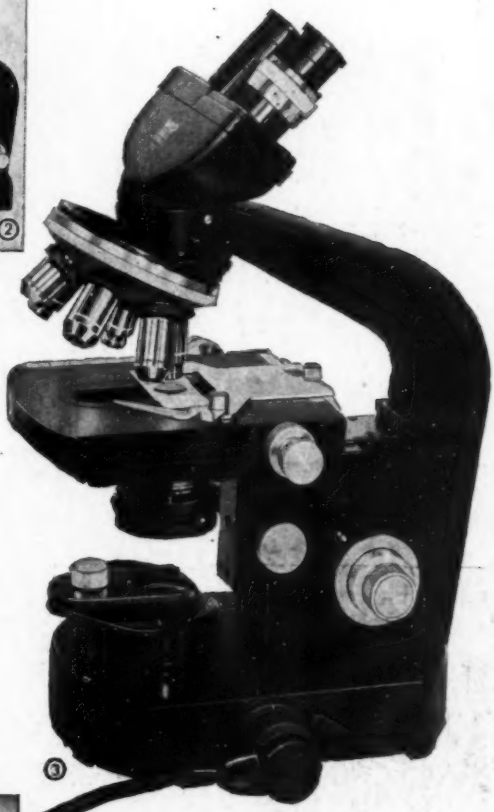

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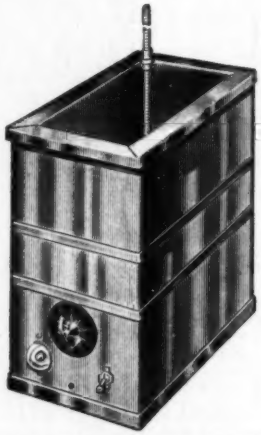

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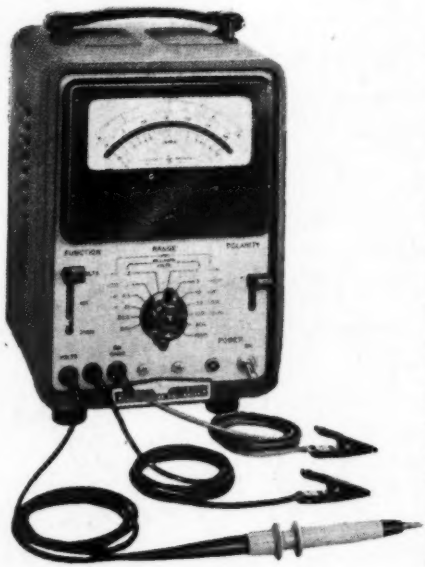

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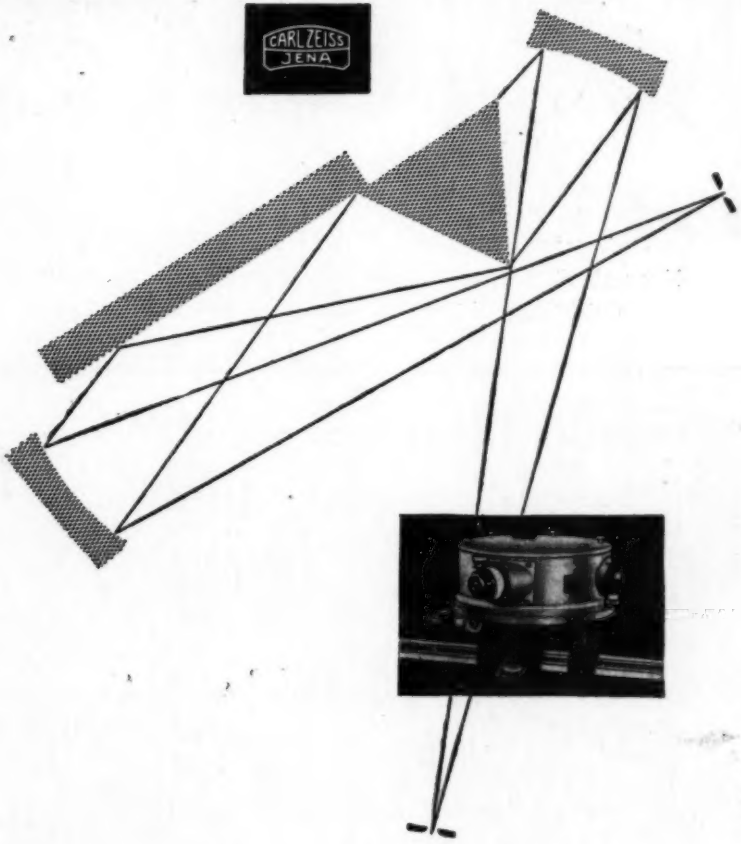

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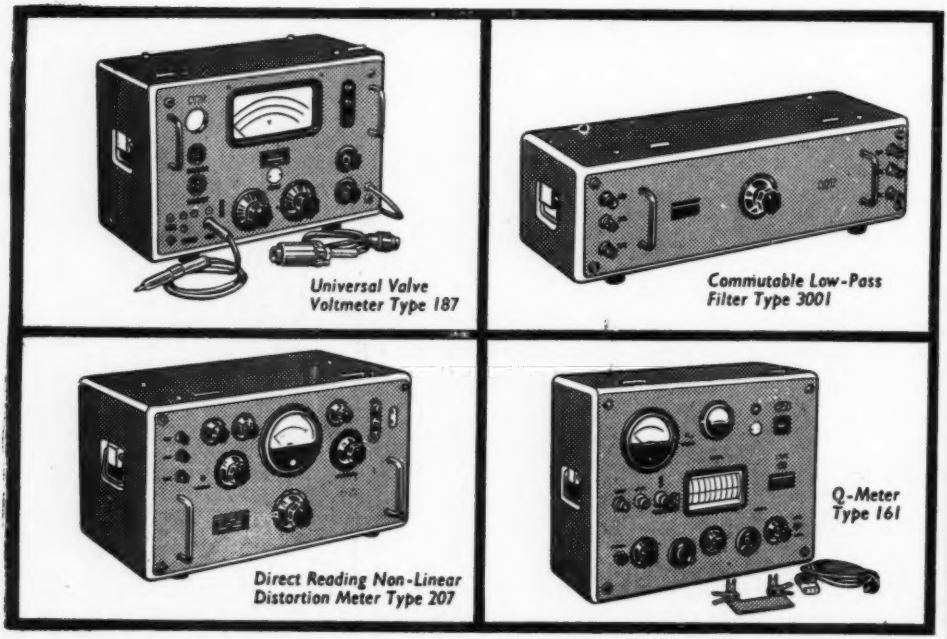

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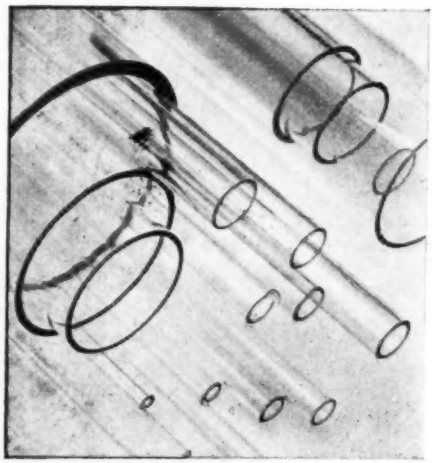

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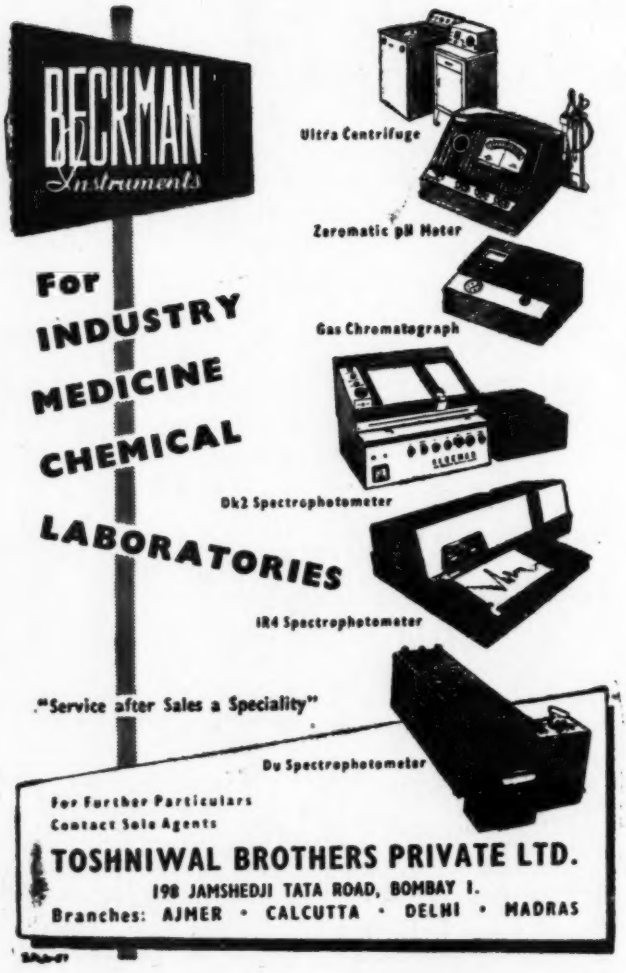
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THE SEARCH FOR FOSSIL METEORITE CRATERS—I

C. S. BEALS, M. J. S. INNES AND J. A. ROTTENBERG
Dominion Observatory, Ottawa, Canada

INTRODUCTION

INVESTIGATION of meteorite craters on the earth's surface has drawn much of its inspiration from analogies with prominent features of lunar topography. This interest has been enhanced by recent studies of the moon by Kuiper and others using the methods of conventional astronomy as well as by the Russian rocket experiments some of which have succeeded in photographing the side of the lunar surface normally invisible to us. There is by no means unanimous agreement among scientists as to the origin of the conspicuous circular lunar features. One general school of thought, which has included numerous geologists as well as some astronomers, attributes the major lunar craters to volcanic or other types of geologic forces peculiar to the moon itself and not in any way due to outside forces.

The ablest and most thorough exposition of this view has been given by Spurr (1944, 1948) who accounts for the craters as a consequence of the outburst of gases from the moon's interior accompanied in some cases by subsidence and other volcanological phenomena too complex for brief description. He explains the different character of various craters in part by the difference in the state of the moon's crust at the time the outburst occurred. Other exponents of "geological" or "volcanological" explanations depend heavily on analogies with earthly volcanism and indeed it appears that for some of the smaller circular features of the moon's surface an explanation in terms of volcanism is a very reasonable one. Kuiper (1959) has recently presented evidence pointing to the presence on the moon's surface of a number of volcanic cones with associated calderas and he has also suggested that a number of essentially rimless craters, some of which are associated in chain-like patterns, are actually blowholes where high pressure gases within the moon's crust have found outlet.

In spite of this rather convincing evidence for the existence of volcanism on the moon it now seems doubtful whether any theory too simplified or exclusive in its basic assumptions will be able to account satisfactorily for the entire range and complexity of lunar phenomena. It has, in fact, been generally agreed that the great majority of lunar craters do not correspond either in shape or distribution to any volcanic phenomena with which we are familiar on earth. Spurr has recognized this fact and has suggested as an explanation that most of the lunar craters were formed at a time when the moon's surface was in a state very different from that of the earth during the known eras of terrestrial geology. While this is an argument that cannot be entirely disregarded, its force is lessened by the increasing evidence of close similarity in shape between the typical lunar crater and a number of meteorite impact craters which have been discovered on earth. The implications of these similarities have been discussed in a good deal of detail by Dietz (1946), Baldwin (1949), Kuiper (1949, 1954), Urey (1952) and others who have presented strong evidence that the great majority of lunar craters are due to the impact of meteorites on the surface of the moon. Some of the characteristics shared by lunar and terrestrial impact craters are as follows:

They are circular depressions of considerable depth with raised edges, having generally different proportions than ordinary volcanic cones and calderas. The central part of the crater dips below while the rim of the crater is raised above the surrounding plain so that on balance there is neither addition to nor subtraction from the surface. The slope of the inner is much steeper than that of the outer walls. The craters of small and moderate size appear deeper than the larger ones but this is an illusion caused by the fact that the ratio of depth to diameter is greater for the smaller objects. Actually there is a regular though non-linear increase in depth with diameter.

These characteristics are also shared by the craters produced by high explosives on the earth's surface and fortunately for purposes of comparison some of these explosion pits are as large or larger than some of the smaller terrestrial meteorite craters. The general similarity which exists between explosion or bomb craters, meteorite craters and lunar craters is illustrated in the accompanying diagram, Fig. 1, due to Baldwin (1949), in which the logarithm of the depth in feet is plotted against the logarithm of the diameter. As will be seen from this diagram, the plot of bomb craters, meteorite craters and lunar craters is traversed

centrally by the curve in such a way as to suggest that these three types of craters are of essentially similar origin. This suggestion of a similar origin is made more convincing by the fact that there are now no gaps in the curve, the meteorite craters overlapping the bomb craters in its lower part and the lunar craters above. The obvious inference to be drawn from Baldwin's curve and from other recent studies of the moon, in particular those of Kuiper, is that both the earth and the moon have been subjected to heavy bombardment by meteorites. From this it would appear that meteorite impact must be added to volcanism as a factor influencing lunar topography and that impact is indeed the dominant factor of the two. On the moon, due to its lack of an atmosphere or a hydrosphere, most of the evidence for meteorite bombardment has been preserved while on the earth most of it has been obliterated due to the agencies of erosion and deposition.

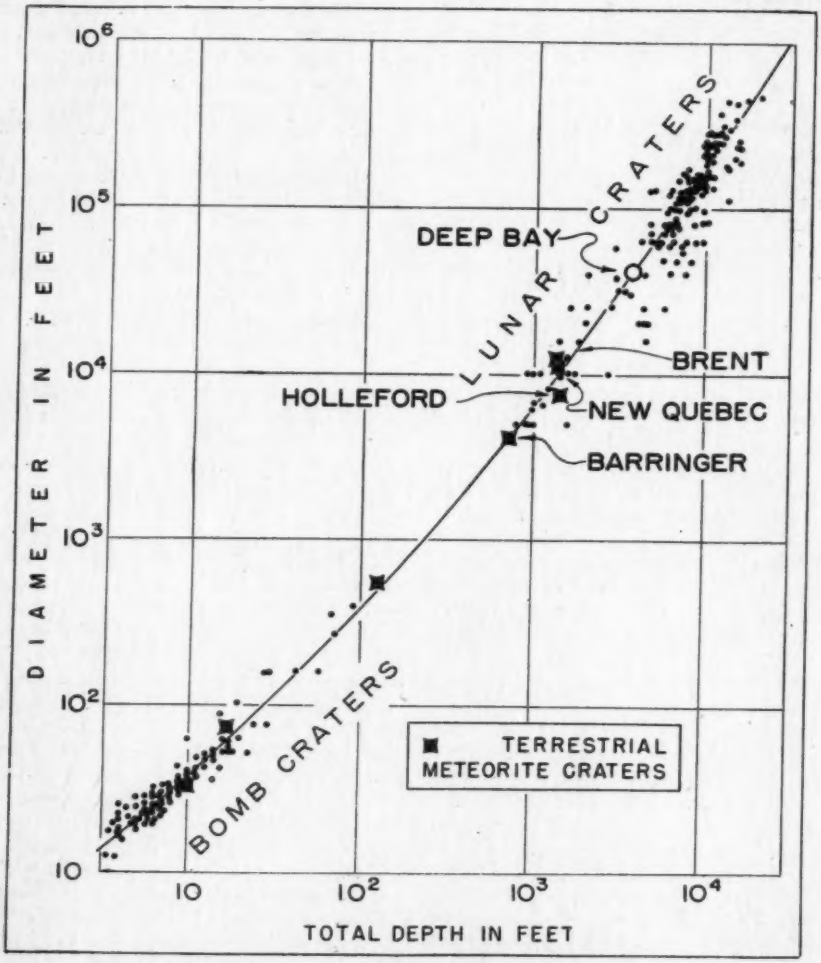

FIG. 1. Baldwin's curve relating crater depth to diameter.

Of the few (about 10) well authenticated terrestrial meteorite craters of size comparable to the smallest observable on the moon, all are of recent origin and this is in accord with expectation since an object of the general character

of a meteorite crater should be eroded away or covered over in a geologically brief space of time. These processes of destruction and concealment are, however, seldom complete and evidence for this is to be found in the vast number of ancient geological formations laid bare in river canyons, sea cliffs, fault scarps and other locations, including artificial rock cuttings, all over the world. It thus seems reasonable to expect that if the earth was at one time subjected to a meteorite bombardment comparable to that of the moon, some evidence of it should still remain to be discovered provided a sufficiently intense search were made for it. The first requirement for such a search is a knowledge of the complete structures of explosion craters and this means not only those parts of the craters visible on or above the earth's surface, but also the subsurface parts of the structure since for many objects this subsurface portion might be all that is left to observe.

Theory of Crater Formation

Granted the proposition that a large enough meteorite of asteroidal origin can penetrate the Earth's atmosphere with only a minor loss of momentum, the problem of the formation of a crater by mechanical impact becomes a study of the question: how does an initially downward, directed motion of the surface of the Earth at the point of impact become converted into a predominantly upward, directed motion of the ground as the large-amplitude stress wave produced propagates the energy away?

A satisfactory quantitative answer to this question requires a knowledge of the response of solids to finite-amplitude deformations, for which physicists have coined the name Rheology. Small-amplitude disturbances (the familiar elastic waves of the seismologists) are much better understood processes. The rheological problem in its present form dates from the nineteenth century when, as a result of the advances in thermodynamics, it became clear that no simple interpolation between the equation of state of gases and the stress-strain relation of an elastic solid would do order-of-magnitude justice to the behaviour of viscous fluids on the one hand and plastic solids on the other. Indeed, physicists today are still struggling with models of inelastic behaviour such that it is usually easier to find a substance which approximates one of the models than it is to reach into the literature and select an equation of state to fit a given solid (Reiner, 1958).

Within the last year, however, a number of nuclear explosions have been detonated in underground conditions, where data are available on the initial conditions of the explosive process and on the type of stress-strain relation applicable to the rock in which permanent damage is produced. For these explosions the excellent agreement between mathematical prediction and measurement, as concerns the arrival times of the shock wave, confirms the theoretical picture of the process as a large amplitude shock wave of decreasing velocity of propagation (Johnson, 1959).

In brief, the energy released in the detonation is propagated through the surrounding rock as a shock wave of so large an initial energy-density that out to radius 0·05 R the rock is vaporized, to radius 0·07 R it is melted, to radius R it is crushed and to radius 2 R it is fractured. Here R, the radius of crushing, is taken to be the dimension most easily identifiable in an enclosed detonation. The velocity of the front decreases as $\cdot 03/r$, if the distance r is in kilometres and the speed in km./s.

Adopting a similar point of view let us consider first of all the penetration of a meteorite of mass m_0 and velocity v_0 into rock of density ρ. In a layer of thickness ds, let the meteorite velocity be v, the loss of momentum $-d(mv)$ and the gain of momentum by the ground $A\rho v ds$, where A is the cross-sectional area of the meteorite. Then

$$m_0 dv = -A\rho v ds \quad \text{or} \quad \frac{dv}{v} = -\frac{A\rho}{m_0} ds \qquad (1)$$

which integrates to

$$\frac{v}{v_0} = \exp\left(\frac{-M}{m_0}\right)$$

where $M = \int A\rho ds$ is the mass of ground set in motion. If we take the calculation as valid till the speed has decreased to the speed c of sound in rock, then $M = m_0 \log_e (v_0/c)$. For $c \simeq 6$ km./s. the penetration can range from 1 to 6 times the meteorite diameter, depending on (*a*) its initial speed, and (*b*) whether it is stone or iron.

If we look upon the results of the nuclear tests as the first consistent measurements in the range with which we are concerned, then we are provided with the very important information that the speed of the shock wave falls off as r^{-1} until the velocity of sound in rock is reached. Combining this with the demonstrated exponential retardation of the impacting meteorite, we find that the Rainier nuclear event would correspond to a small meteorite that penetrated only a metre before being slowed to shock speeds. Data from the same source (Johnson, 1959) indicate that the pressure in the shock

at these distances is some 6 megabars. This corresponds to a nuclear detonation in which the products of the detonation were permitted to expand into a room until the temperature had dropped below 10^6 K° before contact with the walls.

Such a meteorite would nonetheless vaporize the rock to more than 2 metres, melt it to more than 3, etc. To simulate the very large meteorites by a controlled nuclear detonation, one would have to scale all dimensions up—however, the "muffling" of the nuclear blast by letting it first fill a chamber in the simulated case would have to be made comparable to the Rainier event, so that again the shock wave in the rock starts out with a pressure of some 6 megabars.

The above considerations apply only to the direction in which the meteorite strikes. Off-axis, the nuclear tests—carried out as they were under conditions of spherical symmetry—would no longer give a faithful representation of the free ground motion and of the manner in which it yields to the large stresses implied by pressures of a thousand times the compressive strength and ten thousand times the transverse strength of the rock. To indicate the motion transmitted to the ground in these off-axis directions and the extent to which one may expect crushing and fracturing to occur, recourse must be had to mathematical considerations which in the present state of knowledge are to some degree conjectural.

Three-Dimensional Finite Amplitude Waves

If the "state-of-the-art" in this branch of physics can be judged from the recent article on the "Mechanics of Deformable Bodies" in the *Handbook of Physics* (Taub, 1958) then the most recent advance in the theory of finite amplitude wave propagation in dissipative fluids is von Neumann and Richtmeyer's procedure for numerical calculation of hydrodynamic shocks (von Neumann, 1950). They used an automatic digital computer to follow step by step the abrupt transitions in density, pressure and internal energy which correspond to the advance of a shock into a dissipative medium.

The case to which their equations apply is the propagation of a wave down a tube. We take this opportunity to present a generalization of their results to 3-dimensional waves and to arrive at much the same conclusions analytically, rather than by numerical calculation. Thus in Lagrangian co-ordinates x_i, we let $\vec{X}(x_i, t)$ be the Eulerian displacement at time t of an element of the medium that was initially at x_i. Let $\rho_0(x_i)$ be the initial density, so that the specific volume $V(x_i, t)$ is given by the equation of continuity

$$\rho_0 V = div\ \vec{X} \tag{2}$$

and the equations of motion are

$$\rho_0 \frac{\partial^2 \vec{X}}{\partial t^2} = -\ \text{grad}\ (p + q) \tag{3}$$

For the equation of energy conservation one writes

$$\frac{\partial E}{\partial t} + (p + q)\frac{\partial V}{\partial t} = 0 \tag{4}$$

in which all dissipative effects are conceived of as arising from the quantity q in the equations of motion (3). The non-dissipative fluid pressure $p(x_i, t)$ and the internal energy per unit mass $E(x_i, t)$ are understood to have their usual meanings, which is to say that E, p, V are assumed to be connected by an equation of state which would take the form

$$E = \frac{pV}{\gamma - 1}$$

if one were dealing with a perfect gas.

For the cases to which we wish to apply the analysis one may introduce the simplification that the displacement field $\vec{X}(x_i, t)$ is irrotational and hence derivable from a potential Φ. Then (3) can be immediately integrated and together with (2) takes the form

$$\vec{X} = \text{grad}\ \Phi \tag{5}$$

$$\rho_0 V = \nabla^2 \Phi \tag{2'}$$

$$\rho_0 \frac{\partial^2 \Phi}{\partial t^2} = -\ (p + q). \tag{3'}$$

Thus if one were entirely free to choose the dissipative function q, waves of the desired kind could be said to propagate in accordance with a second-order wave equation in Φ. The point of view adopted in introducing the dissipative processes into the equations in this manner, however, is the heuristic one of laying down the conditions that q must satisfy. Now from inspection of (2′, 3′) one sees that $(p + q)/\rho_0{}^2 V$ is of the dimensions of the square of a velocity S and from (4) if $[\dot{E} - (\rho_0 S)^2 V\dot{V}]$ remains infinitesimal in any finite region of the medium, small amplitude disturbances (sound waves) will propagate in that region. Moreover the analysis by which von Neumann and Richtmeyer show that the Rankine-Hugoniot conditions for the conservation of mass, momentum and energy across any shock-front are satisfied holds equally well for any area of a front, in the case of 3-dimensional waves. We make the same proviso

that q becomes infinitesimally small at sufficiently large distances from the shock. Our conclusions are therefore the same:

(2-4) describes the propagation of a shock-like disturbance across whose fronts the Rankine-Hugoniot equations hold if $E - \frac{1}{2}(\rho_0 SV)^2$ has infinitesimal variation except at the front. Clearly this is a requirement much like the Chapman-Jouget conditions for the sustained propagation of detonation and deflagration waves in explosives: to wit that the velocity of the sound waves, in the region behind a front across which the state variables take a jump, must be such that small disturbances cannot overtake the front. In the theory of exothermic chemical explosives it is shown that the equation of state of the detonation products is so located with respect to the STP point in a p-v diagram that the Chapman-Jouget conditions are fulfilled and the energy released in the change of state determines a unique speed of the detonation or deflagration wave (Seeger, 1958).

we have said nothing about the geometrical form of the wave front, and the identifiable surfaces of rupture and fracture.

From data on the strengths of rock in static tests we have

YIELD STRENGTHS IN kg./cm.^{2}

	Compression	Shear and Rupture	Tension
Granitic gneiss	$1{\cdot}6\times10^3$	$0{\cdot}16\times10^3$	$0{\cdot}04\times10^3$
Tuff	0·2		0·03

Now for quite good reasons we expect the stress wave emanating from the point of impact to be compressional in the direction in which the meteorite strikes and to produce tensions transverse to this direction. For the part of the wave propagating at ground level we expect the stresses to be predominantly shears, although there is evidence from cratering experiments in

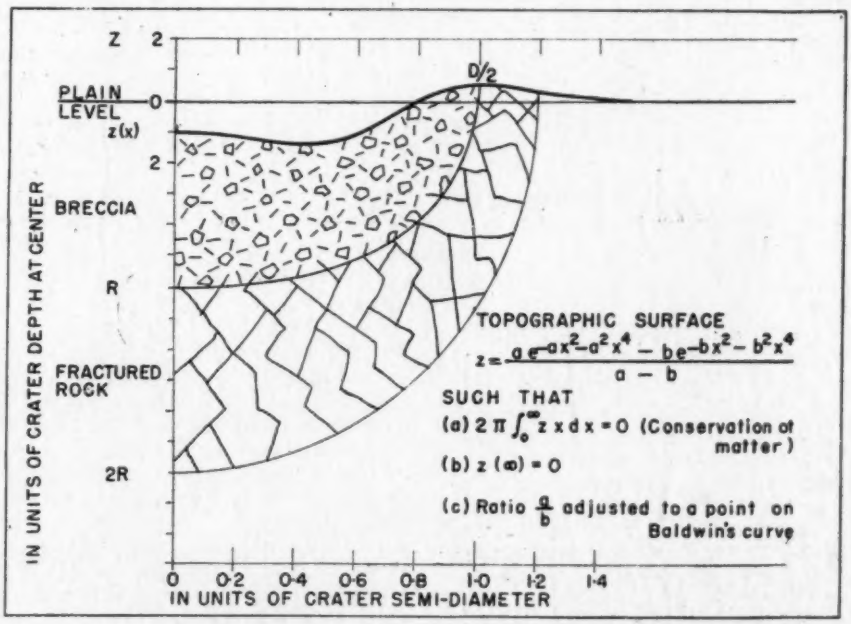

FIG. 2. Calculated profile of a meteorite crater about 1·5 miles in diameter.

In our case the available energy supply is only that energy (enthalpy) present in the transverse tensions which accompany the outward displacements and the shear stresses, so the velocity of the wave must fall as the wave advances, as indeed it does. Thus far, however, clay that this is true of the first arriving part of the wave and that subsequently the medium is pushed outward and thereby subjected to tensional stresses.

To obtain a quantitative relation between R and D in Fig. 2, it is necessary to calculate the

$\vec{X}$ field from (5) for some assumed solution of the equations (2′, 3′) and from this field to calculate the corresponding strains, from which the stresses then follow. Far enough from the point of impact the ground motion must be elastic. We shall not go far wrong therefore in replacing our real problem by a pseudo-problem in which we ask for the displacements brought on by a surface traction such that the free surface is lifted upward and the displacements become vanishingly small at infinity, at least as r^{-2} (Carder, 1959). The simplest such $\vec{X}$ field is given by taking a potential function

$$\Phi = - A \frac{\partial}{\partial z} [x^2 + y^2 + z^2]^{-1}$$

and imagine that we carry out a succession of experiments with increasingly large A, until the yield strengths are exceeded.

Then for a medium in which the elastic properties are known in terms of the Lame constants λ and μ (Love, 1927), we have:

I. On axis of the thrust

$$p_{ij} \propto 2\mu \begin{pmatrix} -3z^{-4} & 0 & 0 \\ 0 & -3z^{-4} & 0 \\ 0 & 0 & 6z^{-4} \end{pmatrix}$$

which states that at depth z there is a vertical compression proportional to $6z^{-4}$, with a tension $-3z^{-4}$ in each of the directions at right angles to the axis.

II. At the free ground surface ($z = 0$), the stress tensor is

$$p_{ij} \propto 2\mu \begin{pmatrix} 0 & 0 & -3x\,(x^2 + y^2)^{-5/2} \\ 0 & 0 & -3y\,(x^2 + y^2)^{-5/2} \\ -3x\,(x^2 + y^2)^{-5/2} & -3y\,(x^2 + y^2)^{-5/2} & 0 \end{pmatrix}$$

which states that the stress pattern reduces to purely shearing forces.

From data on the strengths of rocks given above, we would therefore expect that for a meteorite crater, in granitic gneiss, the surface separating the region of rupture from that of fracture has depth R and semi-diameter D/2, where $2(R)^{-4} : (D/2)^{-4} = 10 : 1$, that is to say a depth of approximately 1/3 the diameter.

To fix the limits of the volume to which fracturing occurs we would have to have recourse to experiments which, insofar as the writers are aware, are still classified. From the Rainier event, however, we have—at least in the direction in which the meteorite struck—that the region of fracture should extend twice as far as the region of crushing and this is in accord with the values appearing in the table for strength in compression *vs.* shear if, as calculated, the pressures fall as z^{-4}.

The result of the application of these principles is shown in Fig. 2.

Hypothetical Types of Remanent Fossil Crater Structures

On the basis of the picture of a typical meteorite crater, given in Fig. 2, it seems worthwhile to try to visualize the sort of remnants or fossil structures likely to be left after the lapse of tens or hundreds of millions of years. Some of the possibilities are outlined as follows:

Type 1. An ancient crater could lose its rim or most of it by erosion and still remain a fairly conspicuous feature such as an approximately circular lake filled with water, the Deep Bay Crater is a good example *q.v.*

Type 2. A crater located in an area never covered by water could by the ordinary processes of erosion gradually become obliterated and disappear as a conspicuous landscape feature. Such an object might, nevertheless, be detected on aerial photographs by configurations of vegetation or drainage patterns.

Type 3. In areas covered by sedimentary rocks where the cover is thin, the circular shape and raised rim of a buried crater may influence the attitude of the sediments sufficiently to be detected, for example the Holleford Crater *q.v.*

Type 4. A crater originally filled in or covered over by sediments may at a later time have the sediments eroded sufficiently to reveal a circular feature, *e.g.*, the Brent Crater described later.

Type 5. A crater filled with sandy or other deposits might, if buried and subjected to heat, pressure and/or silica or calcite recementation, attain a hardness and resistance to solution comparable to that of the containing rock. If subject to severe erosion the altered sediments might retain their structure and identity sufficiently to stand up, at least in some degree above the surrounding plain.

Type 6. A geological study of rock outcrops could reveal uptilted strata in a circular arrangement indicative of a crater formed in sedimentary rock. (The sediments surrounding the Barringer Crater are tilted in this manner.)

Type 7. An ancient crater and its surroundings could be subject to such severe erosion that the original crater surface (whether or not protected by sediments) was completely destroyed leaving only the underlying breccia

whose circular distribution could give a clue to its origin.

Type 8. According to Kuiper who has carried out what are probably the most definitive modern observations of the moon, the central peaks of lunar craters may be igneous intrusions of hard basic rock. A very similar suggestion relative to earthly craters has been made by J. M. Harrison, Director of the Geological Survey of Canada. He points out that an impact of sufficient violence could act as a trigger to release latent volcanism within the earth's crust which could complicate the interpretation of fossil craters. The simplest case would be that of a hard central peak on an earthly crater which might well remain intact while the crater rim, composed of debris and shattered rock would be removed by erosion. To judge by observations of the moon such a situation is most likely to be encountered in a large crater of the order of some tens of miles in diameter. A combination of impact and volcanism also appears to be the most logical explanation of a number of lunar craters with rims corresponding to an impact origin and flat featureless floors probably due to lava flow.*

In a similar occurrence on earth it is possible that the rim would be rapidly destroyed by erosion leaving the lava floor with no very clear indication of its origin except its circular form. There is also the possibility that the volcanic phenomena would be of sufficient magnitude to obliterate all trace of the impact including the original circular crater form.

The Search of Aerial Photographs

The search of aerial photographs in Canada which has been going on systematically since 1955 was originally inspired by the discovery by V. B. Meen (1951, 1957) of the New Quebec crater illustrated in Fig. 3. This magnificent feature, 2 miles in diameter and 1,300 ft. deep was at the time of its discovery the largest meteorite crater known. While it has suffered some erosion, including as Harrison (1954) has pointed out, heavy glaciation, most of its original characteristics have been preserved. The steep slope of its inner walls and the more gentle angle of its outer slopes which merge gradually into the plain, which surrounds it, are characteristic of lunar and meteorite craters (Millman, P. M., 1956). So too is the height of its rim above and the depth of its enclosed circular depression below the general level of the area in which it is located.

Since the New Quebec crater was found in the granite of the Canadian Shield and since this area, comprising almost half of Canada, has

FIG. 3. Oblique view of New Quebec Crater. Diameter 2 miles, depth 1,300 feet.

* Gold (1955) attributes this and other lunar phenomena to dust layers produced by impact. While impact debris undoubtedly plays a part, the writers consider that lava flows are probably more important in accounting for he large level featureless areas of the moon.

remained geologically undisturbed for a very long time, it was considered to be a good place to look for old craters. The Shield consists of Precambrian rock, mainly granites and gneisses but with considerable areas of altered and deformed volcanic and sedimentary rock which show the influence of mountain building forces. In other locations there are large exposures of flat lying volcanic and sedimentary rocks while in the south-eastern part of the Shield, crystalline limestone is an important rock type.

Available for the search was the Canadian Air Photo Library containing about two and one half million photographs which cover most of the mainland area of Canada with vertical photographs taken at altitudes from 5,000 to 35,000 ft. The procedure of search was to examine each photograph carefully for circular features and when one was found, to study it with the aid of a stereoscope to see whether it had any topographic resemblance to a meteorite or lunar crater. In general, this meant looking for objects with raised rims surrounding conspicuous central depressions such as the Barringer or New Quebec craters. The search had proceeded for a considerable time and had involved the examination of several hundred thousand photographs before it was finally realized that such conspicuous features were practically non-existent and that a really effective search would have to concentrate on less obvious aspects of crater structure. This conclusion was reinforced by the discovery of three circular features in which raised rims were inconspicuous though not entirely lacking and which were recognized as explosion craters by their underground features when studied by geophysical methods and diamond drilling techniques. These features could only be described as fossil meteorite craters and since information gained from them will necessarily have a very strong influence on future searches for fossil craters, they will be described in some detail.

The Brent Crater

The Brent Crater (Millman, 1951) was brought to the attention of the Dominion Observatory in 1951 by officials of Spartan Air Services Ltd., of Ottawa, who first noticed the nearly perfect circular feature when viewing high level aerial photographs. The crater is approximately two miles in diameter and is located near the northern boundary of Algonquin Park in north-eastern Ontario. The centre of the crater has co-ordinates, 46° 04·5′ north latitude, and 78° 29·0′ west longitude, elevation 1,150 ft. above sea-level. The southern boundary of the crater is about two and one half miles north of the village of Brent, Ontario, which is a divisional point on the main line of the Canadian National Railway. The crater is inaccessible by automobile but can be reached easily by light aircraft suitable for landing on small lakes, such as Gilmour and Tecumseh, which form part of the crater floor.

The circular pattern of the feature is due to the topography which forms a crater-like depression, the central portion of which has an average elevation some 300 ft. below the hills that rise abruptly in places outward from the central floor. In marked contrast to the rugged terrain of the surrounding areas, there are no abrupt changes in elevation within the basin. Gilmour and Tecumseh Lakes both have about the same elevation and occupy about one-third of the crater ; their western and eastern margins respectively, together with pronounced drainage channels into them, are largely responsible for the circular pattern which first called attention to this region.

Beyond the circle and for a distance of about two or three miles, the drainage is for the most part radial and toward the depression. The only exception is the channel to the south-east, which in seasons of high water provides an outlet through Brant Lake and Cedar Lake to the south. The whole area of the Brent crater is heavily wooded. Spruce, pine and other coniferous trees generally occupy the slopes and surrounding hills, while maples and cedars prefer the lower elevations within the crater.

Geologically the Brent crater lies in an area in which all the rocks with the exception of a few scattered outliers of Palæozoic limestone, are of Precambrian age. The predominant rock types, which outcrop in numerous places on the rim and surrounding hills are gneissic granites and biotite-hornblende-garnetiferous gneisses believed for the most part to be of sedimentary origin. A thick mantle of glacial drift and unconsolidated material consisting of sand, gravel, boulders and clay obscure the crater floor and no bed-rock exposures have been located. However, numerous blocks of Ordovician limestone and shale were encountered along the eastern margin of Gilmour Lake and along the north-south arcuate ridges in the centre of the basin. It was not surprising therefore that blasting operations in connection with the geophysical investigations disclosed Palæozoic rock *in situ* at various depths and made it probable that the entire basin is underlain by sedimentary rocks.

Continental glaciation has affected this whole area with the deposition of great thicknesses of glacial debris particularly in areas of lower elevation. The dominant structural features of the gneisses, however, may readily be observed on the ridges, and field investigation and examination of air photographs reveal no evidence to suggest a geological origin for the crater. The

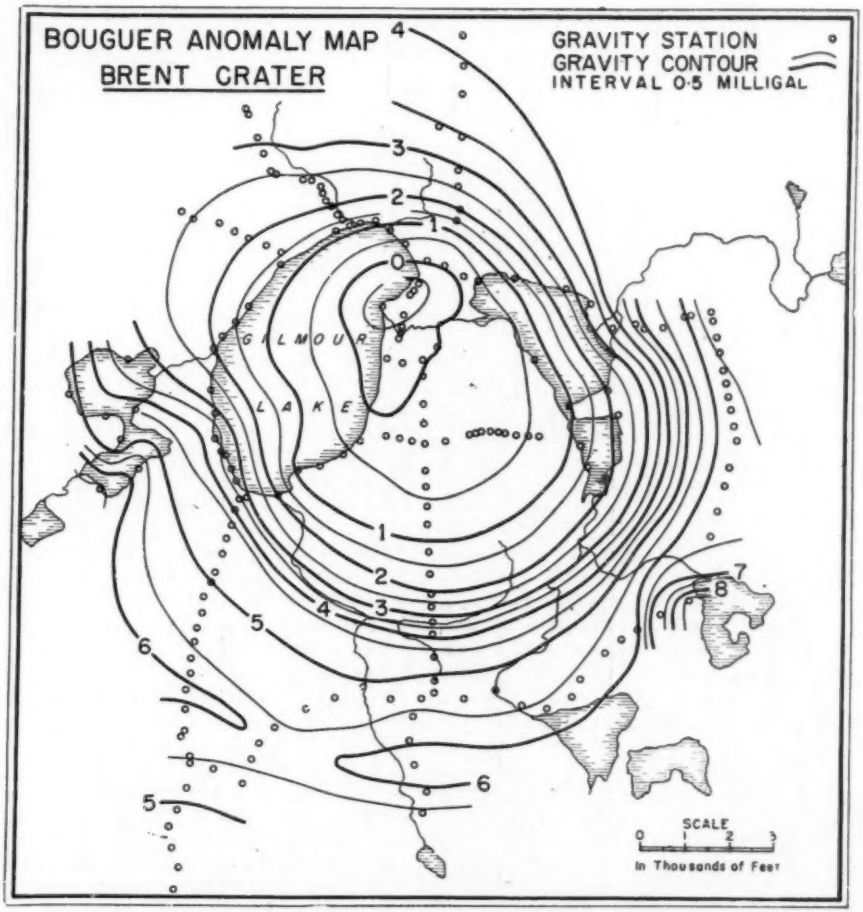

FIG. 4. Gravity contour map. Brent Crater.

trends of the gneisses are generally westerly to north-westerly, and appear to be terminated by the circle defining the present crater wall. In no way do these trends appear to conform to the circularity of the feature, which seems strong evidence that the folding and deformation of the gneissic rocks antedates the crater's formation. Although the gneisses have been subject to large-scale faulting, the near perfect circularity of the crater floor indicates no differential movement and rules out the possibility of faulting and subsidence as a mode of origin. On the other hand, the drainage channels occupied by intermittent streams emptying into the crater might well be the expression of radial tensional features produced at the time of the crater's formation. It should also be remarked that any suggestion that the crater is the deeply eroded vent or caldera of an ancient volcano, finds no support from the surface geology. Apart from the possibility that here as elsewhere in the Canadian Shield some of the gneisses may be of volcanic origin, no volcanic rocks are known to exist in the area.

Perhaps the strongest field evidence for an explosive origin for the Brent crater is the discovery of several outcroppings of breccia along the circular drainage channel which separates the granitic rocks from the crater floor, as well as numerous blocks of breccia within the glacial drift. The breccia is made up of angular fragments of granite gneiss of all sizes from minute particles to blocks measuring several feet across which are indistinguishable from the paragneisses which form the surrounding hills.

The presence of Ordovician sedimentary rocks now filling the Brent depression is evidence of its great age, at least 400 million years, but probably much older and it is not surprising that its original form has undergone great changes through processes of erosion since its formation. Assuming an original rim diameter of 11,500 ft. (Millman *et al.*, 1960), Baldwin's formula as it applies to normal explosion craters, leads to values of 1,555 ft. and 662 ft. for the total depth and rim height, respectively, and hence 893 ft. for the depth of the crater floor below the original ground level.

There seems little doubt that the original rim of the crater has been almost obliterated so that its true diameter is very uncertain. Its present form as marked by the height of land is much wider than and extends some 3,000 ft. beyond, the well-defined 9,500-ft. circle that delimits the crater floor. Intensive jointing and fracturing and the formation of multiple tension-fissures would tend to promote and accelerate erosion of the rim. On the other hand, it seems likely that the advance of the Palæozoic seas and deposition of sediments within have contributed to the preservation of the deeper portions of the crater.

Geophysical Investigations

Obviously, if the Brent crater were a true explosion crater, the great amount of energy expended in its formation would result in marked changes in the physical properties of the country rock, not only at the point of impact but in the area surrounding the crater. Accordingly, geophysical investigations employing gravity, seismic and magnetic methods were carried out (Millman *et al.*, 1960) in the expectation that they might provide important information to test the validity of an explosive origin.

(*a*) *Gravity Measurements.*—The gravity anomaly map Fig. 4 gives the important results of the gravity investigation. The location of the gravity stations and their Bouguer anomalies contoured at intervals of 0·5 milligals are shown. Some topographical information which outlines the depression has been included, and it is readily seen that apart from minor variations, the gravity contours are circular and form a gravity minimum of about five or six milligals concentric with the crater.

Any explanation of the gravity pattern would require a circular body consisting of material of lower density than the surrounding gneisses and extending from near the surface to a considerable depth. If it is assumed that the low density body is due entirely to Palæozoic strata filling a depression in otherwise undisturbed Precambrian rocks, some 1,600 to 4,000 ft. of sedimentary material, depending upon its density, would have to be present to account for the total anomaly.

However, density determinations of samples of the gneiss breccia previously described yield values all lower than the densities obtained for the surrounding granitic gneisses, but which have a range similar to that of the Palæozoic rocks. This suggests that a considerable portion of the gravity anomaly is due to broken and fragmental material underlying the sediments. The assumption that the latter extend to above 900 ft., the predicted depth to the original crater floor, leads to an estimate of 700 to 3,000 ft. for the thickness of the brecciated zone.

Other evidence which points to a zone of intense fracturing and uplift of the gneisses in the vicinity of the crater's rim, and which supports the higher value estimated for the thickness of the breccia zone is apparent from the gravity anomaly map. It will be noticed that whereas the variation in gravity, as indicated by the spacing of the anomaly contours, is small over the central floor of the crater, the anomaly gradient is a maximum near the 9,500 ft. circle separating the granitic and sedimentary rocks. There are insufficient gravity observations to delimit the full extent of the gravitationally disturbed zone over the gneisses on all sides of the crater, but the measurements to the south indicate peak or normal values some 3,000 to 4,000 ft. from the circle. This then may be taken as an indication of the outer limit of the zone of major crustal fracturing and deformation which accompanied the crater's formation.

(*b*) *Seismic Investigation.*—As the velocity of seismic waves depends primarily upon the nature of the medium in which they are transmitted, seismic investigations were carried out, with the expectation that significant information

might be obtained about the underlying structure, as well as an estimate of the depth of sedimentary materials within the crater. Ordinary refraction methods were employed and shots were fired at various intervals along a north-south diameter of the crater and on the north and south rim. Recording seismometers were located at three sites within the crater, and at two sites outside, one to the north and the other to the south each about 2,000 ft. beyond the 9,500-ft. circle. With this arrangement it was possible to record arrival times of seismic waves for shots fired at distances up to 4,000 ft., sufficient to establish characteristic velocities and thicknesses of the material within the crater. In addition, one seismograph was located in the village of Brent, 4 miles to the south for the purpose of determining the normal seismic velocity for this area of the Shield and to provide an estimate of the width of the zone of fracturing in the vicinity of the crater, if such existed.

Analysis of the travel time curves for the stations located within the crater and on the rim yield wave velocities which in a broad way may be interpreted as defining three underlying layers of contrasting elastic properties. The lowest velocity, 1,700 ft. per second, is considered due to glacial drift and the weathered material overlying the bed-rock surface, with thicknesses as great as 100 ft. A velocity of 10,300 ± 170 ft. per second was well established on records for the three stations within the crater and is believed to represent the propagation velocity of the Palæozoic limestone and other sedimentary rocks filling the crater. Data for these stations also yield a higher velocity, 14,150 ft. per second, identified as the propagation velocity of the breccia zone underlying the sedimentary rocks and verified as such from analysis of the time-distance curves for the two long-range stations located on the rim. Although considerable uncertainty remains concerning the actual form of the crater floor, the combined analysis of the seismic data from short- and long-range shots indicates that the sedimentary material has a thickness of about 300 ft. near the rim and that it increases to about 1,000 ft. toward the centre of the basin.

As successive seismic horizons can be identified only if the refracted wave paths are sufficiently long to verify with certainty the velocity of propagation characteristic of the underlying layers, a determination of the thickness of brecciated and shattered rock (14,150 ft. per second material) underlying the sediments is dependent on the seismic data recorded for some distance outside the crater rim. One shot fired near the centre of the crater was recorded at the Brent station at a distance of 20,200 ft. indicating an average velocity of 15,780 ft. per second. Unfortunately because of instrumentation difficulties no other records were obtained to provide a firm value for the normal propagation velocity of the crustal rocks outside the crater. However, on the reasonable assumption that this value is not much different from the average value, 20,240 ft. per second, for the Canadian Shield (Hodgson, 1953), and that the difference in these velocities is entirely due to low velocity materials within and surrounding the crater, the thickness of the brecciated zone is estimated to be of the order of 4,000 ft.

(c) *Magnetic Investigation.*—It is generally known that granitic gneisses of the Canadian Shield produce highly variable magnetic fields, largely due to concentrations of magnetite crystals in contact zones and along bedding planes. Apparently these crystals became polarized under the influence of the earth's magnetic field during the processes of thermal and dynamic metamorphism in which the rocks were transformed into gneisses. Contours of variations in the magnetic field, therefore, tend to follow and outline major structural features and it was considered that magnetic surveys over the Brent crater depression might provide significant information concerning its underlying structure.

Accordingly measurements of the vertical magnetic field intensity were made along certain traverses across the floor of the crater, and on its rim by the Dominion Observatory. In addition the Geological Survey of Canada carried out an aeromagnetic survey at a height of 500 ft., in sufficient detail to provide a contour map of the area giving the variations in the total field intensity. The most significant feature of the results of both surveys, which are in general agreement, is the marked contrast between the intensities observed within and outside the rim of the crater. The total variation in the airborne results over the crater does not exceed 80 gammas with nearly a uniform gradient of about 50 gammas per mile directed to the northwest. On the other hand, the magnetic intensities surrounding the crater are highly disturbed and typical of the magnetic fields associated with granitic rocks in other parts of the Shield. Here the intensities are on the average about 150 gammas higher than over the central part of the crater, with local disturbances giving

rise to steep gradients as much as 600 gammas per mile.

Several factors, all of which are consistent with the hypothesis of an explosive origin, may be mentioned to explain satisfactorily the low magnetic relief associated with the central part of the crater. First of all the aeromagnetic data are influenced by variations in the distance between the magnetic source and the magnetometer. These results are typical of those in areas of deep sedimentation, the widely spaced contours and low gradients being an indication of a considerable depth to the boundaries between rocks of contrasting magnetic properties. While the great thickness of sedimentary material now filling the crater would contribute considerably to the decrease in magnetic intensity because of its lower and more uniform susceptibility compared to the surrounding gneisses, the great volume of fragmental rock and breccia underlying the sediments most likely is responsible for the major effect. Impact and explosion would disrupt the systematic alignment of the magnetic materials within the gneisses to form a random distribution of magnetic poles within the brecciated zone, thus resulting in a general decrease in the magnetic field intensity.

(d) *Diamond Drilling Program.*—The gravity, seismic and magnetic observations were all in remarkably satisfactory agreement in indicating the presence of a crater of considerable depth filled with material of lower density, lower seismic velocity and lower magnetic susceptibility than the surrounding granitic rocks, all consistent with the meteoritic hypothesis of an explosive origin. A drilling program was therefore undertaken to determine the shape and depth of the crater and to examine the nature and extent of the brecciated rock indicated by the surface geology and geophysical results to underlie the Palæozoic sediments.

FIG. 5. Drill cores showing breccia near edge of Brent Crater.

The first phase of the drilling program was carried out during the winter of 1955 and two holes were put down, Hole No. 1 midway along the eastern shore of Gilmour Lake and Hole No. 2 near the southern end of the lake, about 250 ft. north of the contact between the granitic and sedimentary rocks. Unfortunately too light equipment was used and because of the difficulties encountered, due largely to lack of proper casing, it was found necessary to abandon both holes before reaching the undisturbed Precambrian floor. However 554 ft. of undisturbed Palæozoic strata were penetrated by the drilling in Hole No. 1, and 58 ft. in Hole No. 2. In the latter gneiss breccia was encountered at a depth of about 150 ft. and continued for 52 ft., to the bottom of the hole. The character of the breccia is illustrated in Fig. 5.

A second drilling program was carried out with much greater success during the winter of 1959 using heavier equipment. Only one hole was attempted, Hole No. 3, located as closely to the centre of the crater floor as was possible during the winter months. Proper casing was used and practically all the core recovered from the surface to a depth of 3,500 ft. where the drilling was stopped. It was found that the Palæozoic strata were penetrated at a depth of 851 ft. indicating that the floor of the crater has an elevation of about 250 ft. above sea-level or a depth of 1,080 ft. below the mean level of the surrounding country. The depth is 150 ft. greater than that predicted from Baldwin's relation applied to the original estimated rim diameter of 11,500 ft. and while this could be accounted for on the basis of a normal observational scatter of points about the curve, it is also possible that the above estimate of rim diameter is too small. The problem of estimating the original plain level is indeterminate since the original Precambrian terrain was probably mountainous and there is no means of knowing the amount of erosion which has taken place during the great span of time (over 500 million years) since the crater was formed. On the most simple assumption possible

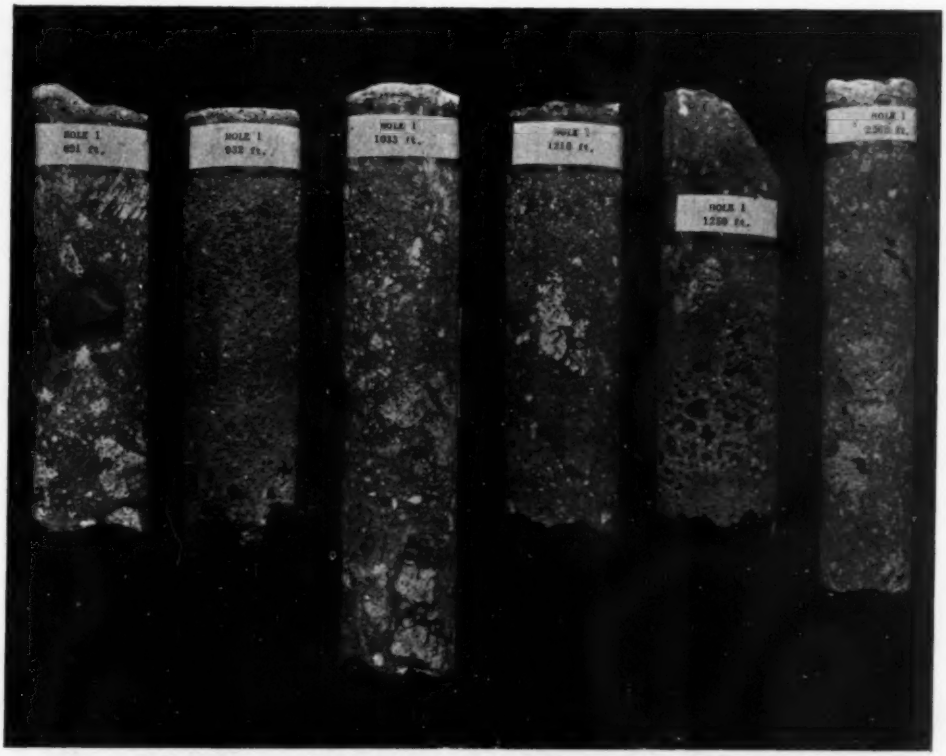

FIG. 6. Drill cores showing breccia and melted rock near centre of Brent Crater.

(i.e., no erosion) the depth below plain leads to an alternative rim diameter of 14,700 ft.

Underlying the sedimentary column, fragmental material and gneiss breccia, similar to that discovered near the rim of the crater and in Hole No. 2, were encountered and continued to a depth of about 3,000 ft. or more. The breccia consists of fragments of all sizes from minute particles to large blocks several feet in thickness, generally increasing in size with increasing depth so that no definite level could be established for the horizon separating the fractured zone from the undisturbed granitic rocks. Measurements of the drill core samples indicate that the breccia has a mean density of about 2·51 gm./c.c. varying slowly from about 2·37 near the top of the zone to about 2·63 at the bottom of the hole. As the mean density of the surrounding granitic gneisses is about 2·67 gm./c.c., it would appear that Hole No. 3 at a depth of 3,500 ft. does not altogether reach the undisturbed basement rocks.

Also supporting the meteoritic impact and explosion theory of origin for the Brent crater is the evidence of the extreme heat to which the fragmental material has been subjected, particularly in upper 600 ft. of the breccia zone. Figure 6 shows photographs of selected core samples for various depths at the centre of the crater. The four cores from levels 932 ft., 1,033 ft., 1,218 ft. and 1,250 ft., if carefully examined, all appear to have been partially melted but in varying degrees. It is interesting to note however that even in the cores from levels 932 ft. and 1,250 ft., which contain the larger vesicules and which presumably have undergone a greater degree of melting, the fragments of granitic gneiss are still distinguishable. Only the cores from the centre of the crater show the effects of heating, no specimens of pumice being found in the cores obtained near the circumference. Another feature of great interest was the discovery that portions of the cores in the upper part of the breccia zone contain irregularly shaped pieces of dark-coloured material that is highly magnetic, the magnetism being due to the presence of magnetite but without nickel. As only a cursory examination of the cores so far has been completed, the full significance of this magnetic material must await further study. The evidence as a whole suggests that the Brent feature is a fossil meteorite crater of Type 4.

CONTINUOUS SPECTRUM OF THE SUN AND THE NEGATIVE HYDROGEN ION

INVESTIGATIONS on the absorptive power of the solar atmosphere for radiation of different wavelengths, first published by Milne and later extended by other workers show that the absorptive power increases by a factor of the order of two as the wavelength increases from 4000 to 9000 Å; beyond 9000 Å the absorptive power decreases by about the same amount until we reach 16000 Å in the infra-red; and again it increases as we go further into the far infra-red. One of the principal problems of astrophysics was to determine the source of continuous absorption in the solar atmosphere which will show the behaviour mentioned above. In a series of papers published about fifteen years ago, Chandrasekhar *et al.* established the unique role which the negative hydrogen ion (H^-) plays in determining the character of the continuous spectrum of the sun and the stars. In particular Chandrasekhar and Breen showed that the theoretical continuous absorption coefficient, K_ν, of the negative hydrogen ion, including the free-free transitions, gives a satisfactory account of the solar continuous spectrum from λ 4000-25000 Å.

However, the calculated coefficient for the free-free transitions seems to be somewhat too large when compared with the one deduced from the observed spectrum. In their work the Hartree wave functions (without exchange) were used for the initial and final states. It is known, however, that the effect of electron-electron exchange and correlation (i.e., polarization) is quite appreciable for the bound state of H^- and one expects this exchange and correlation effect on the S-waves of low energies in the continuum to be important.

In a recent paper (*Astrophy. J.*, 1960, 131, 25) Ohmura and Ohmura take into account the exchange and the polarization effects for the S-electrons in the calculation of the free-free absorption coefficient, and find that these effects reduce the absorption coefficient for free-free transition by 40-50%, thus improving the agreement between the calculated K_ν and the empirical K_ν in the infra-red region.

AN ENTOMOGENOUS FUNGUS (*EMPUSA* SP.) PARASITIC ON THE SYRPHID *SPHAEROPHORIA SCUTELLARIS* F.

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DURING March 1959, the adults of a syrphid fly, *Sphærophoria scutellaris* (F.), which were visiting the flowers of Umbelliferæ at I.A.R.I., New Delhi, were found killed by a disease. The disease which was localised and restricted to a few plants in a particular field, spread over a large area in the course of a fortnight, when hundreds of flies were found dead. The diseased flies were found dead with open wings, the proboscis, legs and the tip of abdomen being firmly glued to the plant. A close examination of the diseased flies revealed the presence of spores of a fungus in the abdomen. The fungus causing the disease was identified as *Empusa* sp. Steinhaus[1] mentions *Empusa muscæ* Cohn., as one of the common entomophthoreæ fungi attacking a number of Diptera, in addition to the common house-fly.

Symptomatology

In the advanced stage of the disease, just before death, which probably occurs 2 or 3 days after infection takes place, the syrphid fly, after alighting on the inflorescence, assumes an elevated position and soon restless movements are noticed. It slowly looses its hold but clasps the twigs with the legs by coiling round, the wings remaining open. After death which occurs while they are in this position, the legs and proboscis stiffen and the dead fly is firmly glued to the plant in life-like position. About 5 to 7 hours after death, a fine fluffy growth appears from the intersegmental membrane of the abdomen of the insect. The whitish growth soon develops a large number of conidiophores which give rise to bell-shaped conidial spores. The spores are discharged by wind and a fine deposit of whitish spores can be seen on the pedicels and petals of flowers just below the dead insect.

The dead flies remain in this position for more than a week until they are finally blown off by wind or eaten away by predators. The adults of the coccinellid, *Coccinella septempunctata*, were noticed to feed on the dead flies but the beetles seem to be unaffected by coming in contact with the fungal spores or devouring the diseased flies.

Nature of *Empusa* Infection

Infection of the insect by the fungus is apparently through the inner intersegmental areas of the body-wall and appendages. A healthy syrphid fly, when it moves about in the flowers in search of pollen and honey, comes in contact with either the diseased fly or the flowers carrying the fungal spores. In this way all those flies which visit the contaminated inflorescence are affected within a short time. The natural infection in the field rose up to 60% in the course of three weeks.

Soon after the fungus spores come in contact with the integument of the insect, they begin to germinate, sending out conidial hyphæ that penetrate into the body cavity of the host. In the laboratory healthy syrphid flies could be infected with *Empusa* fungus experimentally. This was accomplished by releasing healthy flies in a cage containing contaminated plants collected from the field. The disease could also be brought about in healthy flies by transferring the fungal spores to the abdomen by a brush. Some of the experimentally infected flies failed to produce the external growth of conidiophores after death of the fly.

Economic Importance

S. scutellaris is a common pollinator of cultivated plants, especially the Umbelliferæ. The larva of the syrphid is also an efficient predator on different species of aphids. In nature, as many as three dozen or more insects visit the flowers of umbelliferæ, but *S. scutellaris* is the only insect which appears to be susceptible to the disease. The occurrence of the disease in natural environment is of great significance in view of the economic importance of the syrphid fly.

A few specimens of a species of *Musca* apparently killed by *Empusa* were also collected from the same field. If a strain of *Empusa* which could attack the house-fly in India could be discovered, it would open up immense possibilities to control the serious enemy of man by the dissemination of disease among them. Further work is in progress and the full details will be published elsewhere.

Our thanks are due to Prof. C. V. Subramanian, Division of Mycology, for his kind help in the identification of the fungus. Our thanks are also due to Dr. E. S. Narayanan, Head of the Entomology Division, and Dr. B. P. Pal, Director, I.A.R.I., for their interest in this problem.

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HIGH ALTITUDE FISHERIES WITH SPECIAL REFERENCE TO KASHMIR*

APART from J. J. Heckel's first-hand work (1836) and G. T. Vigne's (1842) no detailed account of the fish and fisheries of Kashmir exists, except for a few reports and reviews published from time to time. The River Jhelum and its tributaries, together with the large number of lakes lying in Kashmir, afford a unique opportunity for high altitude fisheries.

McClelland (1838), Gunther (1868), Day (1877-89), Lawrence (1895) and Hora (1954) and later workers have more or less confirmed 18 species of fishes. Of these *Schizothorax* Spp. (Sp. *esocinus* and *planifrons*) with its ubiquitous distribution (Manasbal, Dal Lake near Naseembagh and also Nishatbagh, Anchar Lake, Tehl-Bil Nalla near Khanpur, Jhelum River near Chattabal and Sopore and Baramula, Woolar lake, Arpat River, Achabal Trout hatchery) and medium size (30-40 cm.) is probably worthwhile cultivating extensively. Like the Murrel (*Ophicephalus*) in U.P., M.P. and Bihar this Himalayan Trout *Schizothorax* may still become the poor man's food. This would entail detailed studies on the food habits, habitats and general ecology of *Schizothorax* Spp. As no sand and mud is found in the stomach, possibly it is a mid-feeder on molluscs and insects and also plant material. This would indicate selective distribution of fry and fingerling in only the Eutrophic lakes and fertile streams. The oligotrophic lakes so characteristic of Kashmir would not give a good yield of these fishes.

The hybrids *Oreinus-Schizothorax* of Jhelum may also be investigated since they show sand in their stomachs and may inhabit the bottom niche in the same waters as *Schizothorax*, and since *Oreinus* is definitely rheobiont (running water) and not limnobiont. The feasibility of these species forming a part of high altitude fisheries elsewhere in India may also be tenable.

The genus *Oreinus* (*Plagiostomous*) is distributed in the rivers and lakes in Himalayan and sub-Himalayan regions, extending from Kashmir to Bengal. It is of moderate size (25 cm.) and may be cultivated widely in high altitude fisheries of India. Besides *Schizothorax* and *Oreinus*, the introduction of European Pike (*Esox*), Brown trout (*Salmo trutta fario*), Rainbow trout (*Salmo irideus, S. gairdnerii*), new fisheries could be established as in Kashmir, Himachal Pradesh and Kumaon (U.P.). Mirror corp, *Cyprinus carpio specularis* (as introduced in U.P.) may also be promising and needs consideration for oligotrophic high altitude lakes of India.

S. M. DAS.

* All-India High Altitude Fish Committee, Srinagar, June 1951, Contribution abstract.

AURORAL GREEN LINE IN METEOR WAKES

THE auroral green line 5577 Å which is emitted by metastable atoms of neutral oxygen is a prominent feature in the spectrum of the aurora and night sky. It has also been identified among the low-excitation lines of planetary nebulæ.

The origin of the line in the auroral region and night sky is explained as follows: Extreme ultra-violet radiation, less than 1000 Å, ionizes $O_2 \rightarrow O_2^+$ and $N_2 \rightarrow N_2^+$. In the latter process the charge is given up to O_2 almost immediately. In dissociative recombination, $O_2 + e \rightarrow O' + O''$, where one or both the resulting oxygen atoms may be in an excited state (^1S 4·17 ev, ^1D 1·96 ev). The forbidden transition $^1S - {}^1D$ produces the green line.

In a recent study (*Astrophy. J.*, 1960, 131, 25) of a number of meteoric spectra which were photographed during the years 1955-58, the auroral green line 5577 Å has been found in at least 12 of the spectra. The study reveals that the line is normally confined to the top portion of the photographed trail with an extreme height range of from 120 to 79 km., and that at times of increased solar activity the line appears to persist to lower heights.

An important result that has come out of the investigation is that all meteors showing λ 5577 have been fast meteors. Of the 12 meteors involved there are 4 Orionids (66 km./sec.), 7 Perseids (60 km./sec.) and 1 Lyrid (48 km./sec.). Although the Lyrid was quite a bright meteor, the green line in it is extremely weak.

The excitation mechanism for the auroral line in meteor trains is obscure but probably it involves ionization of either atmospheric or meteoric origin. The strong dependence on velocity also suggests some high-energy quantum processes. In any case it cannot be the same as for normal lines in meteor spectra, including some permitted oxygen lines.

LETTERS TO THE EDITOR

VITAMIN K AND ITS DERIVATIVES AS SUITABLE COLOURING AGENTS FOR VANASPATI

SEVERAL coloured compounds have been investigated in regard to their suitability as colouring agents for vanaspati, but so far none of them has been considered satisfactory. At present, sesame oil is compulsorily added, which can be detected by the "Baudouin" test. Further, vitamin A is also added compulsorily to vanaspati, while addition of vitamin D is optional.

Jayaraman and Ramasarma of this Department have found recently that a wine-red-coloured compound was formed from "Menaphthone" (synthetic vitamin K) in 90% yield after treatment with alumina (unpublished data). Since this highly coloured compound was found to be fat soluble, it was of interest to study whether this can be used for colourisation of vanaspati. It was found that adding 10 mg. of this coloured products to 100 g. of "Dalda" gave a light pink colour to the fat and this coloured fat when mixed with ghee to the extent of 30% was detectable by its colour. However, in order to detect adulteration at 10% level, the addition to vanaspati of "Acetomenaphthone", the acetyl derivative of vitamin K, was studied in view of the ability of this compound at low concentrations to give rise to a deep red colour in presence of sodium hydroxide. 20 mg. of Acetomenaphthone was mixed with 100 g. of 'Dalda' and such a fat was mixed with ghee at 10% level. When 10 g. sample of the adulterated ghee was heated in a water-bath with 3 pellets of NaOH and 3 ml. of water for half an hour, a pink colour developed in water layer which can be easily detected by visual comparison with a sample of pure ghee similarly treated.

The above experiments indicate that it should be possible to colourise vanaspati for psychological reasons to prevent gross adulteration of ghee and also to detect adulteration of ghee with vanaspati at 10% level when acetomenaphthone is added. These compounds are not removed by treatment with fuller's earth and washing soda. Further, though the level of acetomenaphthone used in the above experiments is ten times the prophylactic dose for vitamin K, the toxic dose is several hundred times greater than this level.[1]

However, when the vanaspati was heated above 100° C., the pink colour decreased in intensity and the acetomenaphthone-alkali test gave a yellow colour instead of the original pink. It is, therefore, desirable to try the addition of more stable derivatives of vitamin K, such as the dibenzoate (m.p. 180° C.) as well as of the pink-coloured product. Also studies will have to be carried out to simplify the tests and make them more sensitive so that lower concentrations of these can be added to vanaspati. These investigations are in progress.

The small increase in price of vanaspati which will result from the above additions will be more than compensated by the fact that the vanaspati will have vitamin K in addition to the other fat-soluble vitamins A and D and hence can be considered a better product from the nutritional standpoint.

My thanks are due to Dr. T. Ramasarma for helpful discussions and to Sri P. V. Dakshinamurthy for technical assistance. Thanks are also due to Messrs. Glaxo Laboratories (Private) Ltd., Bombay, for supply of acetomenaphthone.

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June 11, 1960.

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CHROMATOGRAPHIC BEHAVIOUR OF CATIONS

II. Separation of Platinum, Palladium, Gold and Copper

A SOLUTION containing chlorides of platinum, palladium, gold and copper of about 0·01 M concentration was used to separate the metals by circular paper chromatographic method as described in an earlier communication.[1] Several experiments were carried out under a variety of conditions in order to find out optimum conditions for the effective segregation. Individual salt solutions were also chromatographed to determine the R_f values of the cations and also for the purpose of comparison. The cations were identified by spraying the air-dried chromatograms with ammoniacal hydrogen sulphide from an all-glass atomiser.[2] Gold and palladium could be identified by their dark-brown bands while platinum gave orange band and with copper

the usual black band was observed which fades on standing. It was observed that the R_f values of these cations were the same whether they were chromatographed individually or from a mixture. Different primary alcohols (Methyl, Ethyl, Propyl, Butyl, Amyl and Benzyl alcohols) with various concentration of hydrochloric acid were used as irrigating solvents. The R_f values of these metals as obtained with such systems are presented in Tables I and II. The experiments were carried out at room temperature (25 ± 2° C.).

TABLE I

R_f values of copper, gold, palladium and platinum. Irrigating solvent: Alcohol 85 ml., HCl 10 ml., water 5 ml.

Alcohol used	Cu^{++}	Au^{+++}	Pd^{++}	Pt^{++++}
Methyl ..	0·87	0·95	0·97	0·967
Ethyl ..	0·75	0·99	0·967	0·956
Propyl ..	0·73	0·99	0·91	0·93
Butyl ..	0·60	1·00	0·87	0·858
Amyl ..	0·44	1·00	0·70	0·86
Benzyl 100 ml. +10 ml. HCl + 6 ml. water	0·38	1·00	0·52	0·89

TABLE II

R_f values at different concentrations of HCl

100 ml. Butanol saturated with	Cu^{++}	Pd^{++}	Au^{+++}	Pt^{++++}
0·1 N HCl ..	0·242	0·58	0·79	0·55
0·5 N HCl ..	0·27	0·67	0·83	0·73
1 N HCl ..	0·33	0·83	0·90	0·89
2 N HCl ..	0·42	0·92	0·98	0·94
3 N HCl ..	0·51	0·92	0·98	0·96
4 N HCl ..	0·64	0·95	0·99	0·97

Table I shows that the R_f values of cations decrease with the increase in the carbon chain of primary alcohols. It is observed using *n*-butanol saturated with hydrochloric acid of different concentrations as irrigating solvent, that R_f values of cations increase with the increase in acid content as represented in Table II. The *n*-butanol and hydrochloric acid system becomes completely miscible in all proportions when the concentration of hydrochloric acid is above 4·5 N.

The separation of these metals was successfully achieved by using 100 ml. benzyl alcohol mixed with 10 ml. Hydrochloric acid (A.R.) and 6 ml. of water where copper travels slowly ($R_f = 0·38$), palladium and platinum separate completely ($R_f = 0·52$ and 0·89 respectively) and gold is extracted with the alcohol phase which travels ahead of the water front. It is noticed that the R_f values of all the cations increase with the increase of hydrochloric acid content. This increase may be due to the increase in the stability of the complex formed. The boundary of the metallic band becomes sharp as the acid content is increased and in fact the visible intensity of the band increases with the increase of acidity.

It is known that R_f value of a migrating species in a solvent also depends on the shape of the filter-paper[3] used. It can be easily shown that the R_f value on strips is equal to the square of the R_f value on circular paper. The square of R_f values of cations as observed in the present work with *n*-butanol saturated with 1 N hydrochloric acid (Cu = 0·1089, Pd = 0·6889, and Pt = 0·7892) as irrigating solvent compares favourably with values recorded in literature using ascending chromatography with the same solvent[4] (Cu = 0·1, Pd = 0·60, Pt = 0·75). The advantage of adopting circular paper chromatography is that it is more elegant and quicker than the conventional strip method.

Part of this work was carried out at First Grade College, Tumkur. The author's thanks are due to Dr. A. R. V. Murthy of Indian Institute of Science, Bangalore, for the helpful discussion.

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REACTION PRODUCTS OF ZIRCONIUM TETRACHLORIDE WITH PHENOLS AND AROMATIC ACIDS

JANTSCH[1] has reported the formation of zirconium phenolates of the formulæ $(C_6H_5O)_3$ ZrCl and $(C_6H_5O)_4$ Zr. Later on, Funk and Rogler[2] have isolated the products $(C_6H_5O)_3ZrCl.C_6H_5OH$ and $(C_6H_5O)_4Zr.C_6H_5OH$. In the present investigations a reaction between excess of phenol and zirconium tetrachloride gave a phenolate of the composition $(C_6H_5O)_2ZrCl_2$. This interesting behaviour of zirconium tetrachloride has prompted the present detailed study

of its reactions with other phenols and aromatic acids.

Ortho-cresol reacts with zirconium tetrachloride in benzene to yield a disubstitution product $(CH_3C_6H_4O)_2ZrCl_2$ (Found : Zr, 23·92 ; Cl, 18·56, requires Zr, 24·20 ; Cl, 18·88). This compound is very soluble in benzene and sparingly soluble in dry petroleum ether (80-100°). *Meta*-cresol also provides a disubstitution product which is pink in colour, very soluble in benzene and sparingly soluble in petroleum ether (Found : Zr, 24·11 ; Cl, 18·92, requires Zr, 24·20 ; Cl, 18·88). In the case of *para*-cresol the substitution is enhanced and the compound formed corresponds to the composition $(CH_3C_6H_4O)_3ZrCl$ (Found: Zr, 19·54 ; Cl, 7·95 ; requires Zr, 20·30 ; Cl, 7·91). This compound is also highly soluble in benzene and was isolated by adding dry petroleum ether.

Ortho nitro phenol reacts with zirconium tetrachloride to form $(O_2NC_6H_4O)_2ZrCl_2$ (Found: Zr, 20·70 ; Cl, 16·18, requires Zr, 20·78 ; Cl, 16·21) when the reactants were taken in equivalent amounts in benzene. However, with excess of *ortho* nitro phenol a compound without any stoichiometric composition is obtained. Nevertheless *para* nitro phenol in excess reacted with zirconium tetrachlorde in benzene to yield $(O_2NC_6H_4O)_3ZrCl$ (Found : Zr, 16·23 ; Cl, 6·26, requires Zr, 16·80 ; Cl, 6·55).

Pyro catechol reacts with zirconium tetrachloride to yield a compound which corresponds to the formula $(OC_6H_4O)Zr(OC_6H_4OH)Cl$ (Found : Zr, 26·30 ; Cl, 10·15, requires Zr, 26·49; Cl, 10·33). Resorcinol reacts with zirconium tetrachloride under slightly vigorous conditions to yield a disubstitution product corresponding to composition $(HOC_6H_4O)_2ZrCl_2$ (Found : Zr, 24·03 ; Cl, 18·88, requires Zr, 23·95 ; Cl, 18·70).

Zirconium tetrachloride reacts with *meta* and *para* toluic acids to yield disubstitution products corresponding to the formula $(CH_3C_6H_4COO)_2ZrCl_2$ when the equivalent amounts of the reactants were employed. However, with excess of *meta* toluic acid the product isolated conformed to the composition $(CH_3C_6H_4COO)_2ZrCl_2.3CH_3C_6H_4COOH$. (Found : Zr, 10·64 ; Cl, 8·61, requires Zr, 10·83 ; Cl, 8·45) [*meta* $(CH_3C_6H_4COO)_2ZrCl_2$ (Found : Zr, 20·72 ; Cl, 15·99, requires Zr, 21·08 ; Cl, 16·44)].

Work with other substituted phenols and aromatic acids and studies on the structures of these compounds are in progress.

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TITRIMETRIC DETERMINATION OF COPPER USING DIPHENYLTHIOVIOLURIC ACID

IN an earlier communication, gravimetric estimation of copper by diphenylthiovioluric acid was reported by one of the authors.[1] The method has now been extended for the volumetric estimation of this metal. The method involves the precipitation of copper complex from a solution of the copper salt by addition of the ammonium salt of diphenylthiovioluric acid. The insoluble complex is filtered and the residue treated with a solution of sodium hydroxide to give the sodium salt. The mixture is acidified with hydrochloric acid and the liberated diphenylthiovioluric acid is estimated by bromate titration, and the copper content in the original solution is indirectly determined. The method is capable of giving good results especially for estimation of small quantities of the metal. The interaction of bromate with the reagent cannot be expressed by a simple equation and the procedure must be regarded as empirical, as in the case of titrimetric determination of copper by oxime precipitants.[2] On the basis of the average of a number of experiments, it was found that 1 ml. of 0·1 N potassium bromate ≡ 0·1821 mg. of copper.

The following procedure was used for the purpose :—

Copper (about 20 mg.) was precipitated quantitatively by addition of a solution of the ammonium salt of diphenylthiovioluric acid as described in the previous communication.[1] It was filtered on a X-4 sintered glass filter crucible and washed with hot water. The precipitate was dissolved in acetone and the acetone solution was evaporated to dryness. The residue was treated with about 20 ml. of 10% sodium hydroxide solution. The alkali decomposed the copper complex liberating the reagent which formed the sodium salt. The mixture was transferred to a conical flask and acidified with hydrochloric acid. An equal volume of the acid was added in excess and the conical flask was fitted with a two-holed rubber stopper carrying

a dropping funnel and a stop-cock. Sufficient quantity of 0·1 N potassium bromate was added through the dropping funnel so as to give about 10 ml. in excess. The acid concentration in the solution was adjusted to about 3-4 N by addition of water if necessary. The contents were mixed and set aside for about 15 minutes after closing the flask. A measured excess of 0·1 N arsenious oxide solution containing 1-2 drops of methyl orange indicator was added through the funnel. The excess of arsenious oxide was titrated with 0·1 N bromate, using more indicator if necessary. Special care was taken to prevent the escape of bromine while adding arsenious oxide to the closed system. Results of a few such estimations are recorded in Table I.

TABLE I

Serial No.	Weight of copper in solution in mg.		% Error
	Found	Calculated	
1	20·30	20·42	0·6
2	20·26	20·42	0·8
3	20·32	20·42	0·5
4	30·62	30·63	0·03
5	30·51	30·63	0·4
6	30·49	30·63	0·46

Dept. of Chemistry, R. P. SINGH.
University of Delhi, N. R. BANERJEE.
Delhi-8, *February* 13, 1960.

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DETECTION OF MOLECULAR COMPLEXES IN GASES BY ULTRASONIC METHOD

THE marked effect of added gases in increasing the ultrasonic absorption is well known. In the present work, ultrasonic absorption and velocity have been measured in mixtures of carbon dioxide and air, and carbon dioxide and oxygen, at 455 kc. using interferometer method, described in our previous communication.[1] The gases used were dried by passing over phosphorous pentoxide. The results have been graphically shown in Fig. 1.

The results of velocity measurements indicate that below 66% CO_2, the observed velocity in the mixture is additive of the normal velocities in the two gases. Above 66% CO_2, however, the observed velocity is additive of the dispersed velocity in carbon dioxide and the velocity in the added gas.

The absorption measurements in the mixtures show highly anomalous behaviour, the observed absorption being higher than that in the pure components. When the excess absorption, i.e., the difference between the observed and calculated absorption for the mixture, is plotted against the volume per cent. of CO_2, a number of absorption maxima are observed at molecular proportions of $CO_2 : X$ corresponding to 1 : 3, 1 : 2, 1 : 1, 3 : 1 and 4 : 1, where X stands for air or oxygen.

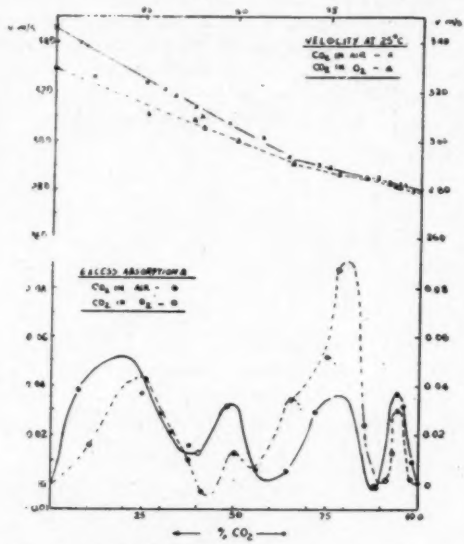

FIG. 1. Velocity and excess absorption against concentration of carbon dioxide at 25° C.

The strongest absorption is at the ratio 4 : 1 (*i.e.*, 80% CO_2) where the observed absorption is nearly twice as that in pure carbon dioxide. The strong resonance in CO_2 molecule will cause effective collisons due to highly polar structures giving rise to maximum absorption. The positive charge on the resonating $O = C = O$ molecule will be attracted by the lone pair electrons in the oxygen molecule giving rise to molecular complex. The other maxima at 25%, 50% and 75% CO_2 can similarly be explained on the basis of formation of molecular clusters or loose complexes in the gaseous state. The method of ultrasonic absorption measurement thus seems to be very sensitive to detect molecular complexes in the vapour phase.

Eucken and Becker[2] reported that the dispersive region is pushed up the frequency scale to 1,000 kc./s. by the addition of 12% impurity

to carbon dioxide. Thus a 5% addition of a foreign gas will shift it to about 500 kcs. The absorption band at 95% CO_2 at the present frequency of 455 kc. is, therefore, due to shift of the relaxation frequency of CO_2.

I thank Prof. S. K. Kulkarni-Jatkar for his keen interest and suggestions in this work which was carried out in the Chemistry Department, University of Poona.

Dept. of Chem. Engg., D. D. DESHPANDE.
Indian Institute of Technology,
Bombay, *April* 14, 1960.

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ISOLATION OF β AND γ-SITOSTEROLS FROM THE LEAVES OF *CLITORIA MARINA* LINN.

THE plant *Clitoria marina* Linn. belongs to Papilionaceæ subgroup of Leguminosæ family and is distinguished from *Clitoria ternatea* Linn. by its light blue to almost white flowers. The leaves of the plant find use in the indigenous system of medicine.[1,2] A systematic chemical examination of the leaves has therefore been undertaken and the isolation of β and γ-sitosterols from the leaves has been described in the present communication.

The crude sterol fraction (2 g.) isolated from the oil obtained from 4 kg. of dry leaves by extraction with petroleum ether was purified by repeated extraction with methyl alcohol and by column chromatography over Brockmann alumina using petroleum ether, ether-alcohol (1 : 1 v/v) and benzene-chloroform (3 : 2 v/v) as the successive eluents. Two fractions of the sterol were obtained from the latter two solvents and were repeatedly crystallised.

The sterol fraction, constituting 60% of the crude sterol, from the ether-alcohol mixture was finally recrystallised from methyl alcohol when shining flakes, m.p. 136°, $[\alpha]_D^{25} - 37{\cdot}0°$ ($CHCl_3$) was obtained. It showed no alteration in specific rotation on crystallisation by the technique of Anderson[3] (Found: C, 84·00; H, 11·96%, M.W. 421, corresponding to the mol. formulæ $C_{29}H_{50}O$). The sterol has thus been identified as β-sitosterol by the preparation of its acetate derivative which melted at 126°, $[\alpha]_D^{25} - 42{\cdot}0°$ ($CHCl_3$) and benzoate derivative which melted at 144°, $[\alpha]_D^{25} - 14{\cdot}5°$ ($CHCl_3$). The regenerated sterol obtained on hydrolysis of these two derivatives was found to contain the original characteristics of the sterol.

The second sterol fraction constituting 40% of the crude sterol, obtained in benzene-chloroform solvent, was crystallised several times from methyl alcohol till it showed no alteration in specific rotation on crystallisation by the technique of Anderson.[3] Its m.p. was found to be 145°, $[\alpha]_D^{18} - 40{\cdot}0°$ ($CHCl_3$), M.W. (cryoscopic in benzene) 418 and contained C, 83·96 and H, 11·88% corresponding to the mol. formulæ $C_{29}H_{50}O$. Its acetate and benzoate prepared in the usual manner melted at 140·0, $[\alpha]_D^{18} - 40{\cdot}0°$ ($CHCl_3$) and 150·0°, $[\alpha]_D^{18} - 14{\cdot}5°$ ($CHCl_3$) respectively. On hydrolysis of these two derivatives the regenerated sterol was found to contain the original characteristics of sterol. The sterol has thus been identified as γ-sitosterol by the preparation of acetate and benzoate derivatives and comparing their percentage compositions, melting-points and rotations with those for known sitosterols.

The characteristics of the β and γ-sitosterols are in conformity with the earlier observations of the author[4] on β-sitosterol from the seeds of *Pongamia glabra* and of Chakravarti *et al.*[5] and Sinha[6] on γ-sitosterol from the leaves of *Aegle marmelos correa* and *Tinospora crispa* respectively.

Pharmacological Lab., A. SINHA.
Division of Chemistry,
Medical College,
Agra, *February* 4, 1960.

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OCCURRENCE OF MONAZITE IN GRANITE-GNEISSES OF KONDAPALLE AREA

THE Kondapalli hills of the Eastern Ghats are well known for the occurrence of charnockites of varied varieties as described by Krishnan[1] and Sriramarao.[2] These charnockites are associated with leptynites, khondalites, granite-gneisses, pegmatites and quartz veins. During the course of the detailed investigations on the rock types of this area included in the *Survey*

of India, topo-sheet No. 65D/10, the author has observed monazite in some of the thin sections of the granite-gneisses. The occurrence of monazite in the Kondapalle hills is not reported earlier, but its presence in the various rock types constituting the Eastern Ghats is reported by Mahadevan and Satapathi,[3] Srinivasa Sastry[4] and Murthy.[5]

The granite-gneisses are pink or brownish-pink in colour and they are fine to medium grained. In thin sections of these rocks, perthite, quartz, garnet and orthoclase occur as major constituents while biotite, magnetite, myrmekite, zircon and monazite occur as minor constituents. Monazite is identified by its yellow colour, high refractive index, high order interference colours, biaxial interference figure and by its optically positive nature. The grains are having dark or brownish-dark border and they are not in juxta-position with zircon or magnetite. The shape of the monazite grains is not constant; some are rounded or oval-shaped while others are nearly euhedral. One of the euhedral grains measures ·044 × ·018 mm. and gives an extinction angle of 9°. The presence of rounded and euhedral grains of monazite in the granite-gneiss, that too in the same thin section (*see* Fig. 1) is significant.

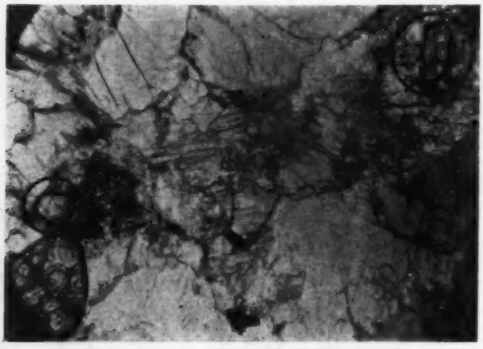

FIG. 1. Monazite (inside the circles) from Granite-Gneiss. Magnification, × 23.

Pichamuthu[6] has discussed the significance of the presence of euhedral or rounded grains of monazite occurring in the charnockites and associated rock types. He has pointed out that the presence of euhedral grains suggests an igneous origin whereas the rounded ones a sedimentary origin for the contained rocks. In that context, the presence of both the types of the grains in the same thin section of the granite-gneiss, offers difficulties to make such a definite demarcation regarding the petrogenesis. So, it may be concluded that great importance need not be given to the shapes of the monazite grains to unravel the petrogenetic problems of the rock types of the Kondapalle area.

The author desires to express his thanks to Dr. S. Balakrishna for his suggestions throughout the progress of this work.

Geology Department, Osmania University, Hyderabad-7 (India), *March* 9, 1960. CH. LEELANANDAM.

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A NOTE ON PHYSIOLOGIC RACES OF *SPHACELOTHECA SORGHI*

Sphacelotheca sorghi (Link.) Clinton, covered kernel smut, is one of the common smuts on *Sorghum vulgare* (Jowar) in which the normal grains are transformed into spore sacs of dirty grey colour filled with dark-brown powdery spores covered by a thin membrane. The disease causes considerable loss wherever jowar is cultivated. *Sphacelotheca sorghi* is known to occur in more than one physiologic forms in Hyderabad (Vaheeuddin, 1950) but none seems to have been reported from elsewhere in India. The results presented here relate to the occurrence of physiologic races of this pathogen in Uttar Pradesh.

Intensive collection of smutted heads of jowars was made from a number of fields in Lucknow and certain other neighbouring districts of the State for three consecutive years (1955-57). Each diseased head after removal was separately placed in a paper bag, duly labelled and stored. For the isolation of the parasitic races several smutted grains from each diseased head were selected and the spores from each individual grain aseptically removed by rupturing the covering membrane were inoculated in potato dextrose, oat meal and Brown's synthetic agar media. A very large number of first generation cultures obtained in this way direct from smutted spores of diseased grains of different jowar varieties all grown under comparable conditions showed that three different races of the fungus could be distinguished,

which subcultured through several generations retained their identity despite certain minor variations and saltations occurring in them. These races proved to be morphologically and physiologically distinct and a reference to the varieties from which these were isolated indicated specialisation in their parasitic activity. It was ultimately estimated that there exist in nature in Uttar Pradesh at least three distinct physiologic races of *Sphacelotheca sorghi*. The following are the distinguishing characters of these races designated as Sp-A, Sp-B and Sp-C as exhibited in potato dextrose agar (20 days growth).

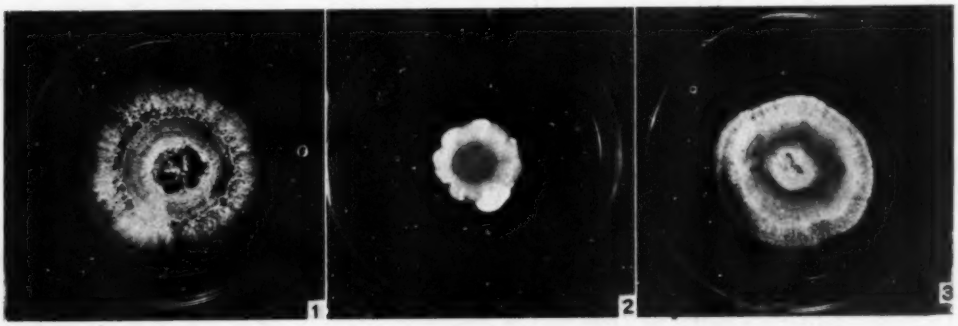

FIG. 1. Sp-A. FIG. 2. Sp-B. FIG. 3. Sp-C.

Sp-A : Colony white ; mycelium cottony ; zonation broad, periphery with hyaline radiating hyphæ ; margin entire, even ; substratum colour white to buff ; diameter 90 mm. (Fig. 1).

Sp-B : Colony snow-white ; mycelium dense, waxy raised in centre ; margin wavy, uneven ; substratum colour light-brown to dark-brown : diameter 40 mm. (Fig. 2).

Sp-C : Colony white ; mycelium cottony, velvety, dense tuft in centre ; zonation narrow ; margin entire, even ; substratum colour white to brown ; diameter 80 mm. (Fig. 3).

Botany Department, S. N. DASGUPTA.
Lucknow University, A. NARAIN.
Lucknow, *May* 4, 1960.

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A NOTE ON THE PERFECT STAGE OF *PHYLLOSTICTA CYCADINA* (PASS)

DURING 1956-59 the authors noted that the infected leaves of *Cycas revoluta* bore the *pycnidia* of *Phyllosticta cycadina* in close association with the perithecia of an ascomycetous fungus which has recently been described by the authors[7] as a new species of *Teichospora* (*T. indica*). It was also observed that late in December or early January, the perithecia of *Teichospora indica* were also produced on the same lesions which were developed earlier on account of the infection by *P. cycadina*. The close and constant association of these two organisms suggested the possibilities of some relationship. The present investigation was started to find out the possible relationship between *P. cycadina* and *T. indica*.

Infected leaves of *Cycas revoluta* which contained both pycnidia of *P. cycadina* as well as perithecia of *T. indica* were collected in the months of December and January. Small pieces of the leaflets of the host were cut from the junction of healthy and diseased portions which were sterilized and placed in agar slants of potato dextrose. About 100 isolated ascospores of *T. indica* and pycnospores of *P. cycadina* were cultured separately. The fungal colonies obtained from the above three sources were examined microscopically at different intervals and they were used for subsequent investigations. Artificial inoculations were made on the leaflets of *Cycas revoluta*. All the three types of cultures were used for artificial inoculations. The inoculated leaves were covered with polyethylene bags. Some bulbils of *Cycas revoluta* were placed in nutrient solution and kept inside sterilized glass chambers. The leaflets arising from the bulbils were also artificially inoculated. Besides the above three cultures the germinated ascospores of *T. indica* and germinated pycnospores of *P. cycadina* were also used for testing the pathogenicity. After three months of artificial inoculation the percentage of infected leaflets was counted and some of the leaflets were microscopically examined for the presence

of pycnidia or perithecia. A preliminary study had revealed that a medium containing dead leaves of *Cycas revoluta* developed the fruiting bodies very readily. The following culture medium was, therefore, prepared. Dead leaves of *Cycas revoluta* 20·0 gm., maltose 10·0 gm., asparagine 2·5 gm., KH_2PO_4 1·75 gm., $MgSO_4.7H_2O$ 0·75 gm., distilled water 1 litre 2·0% agar was added to solidify the medium. Ascospore germination in 0·2% maltose solution was also studied.

Isolation experiments showed that infected leaves of *Cycas revoluta*, as well as the pycnospores, always yielded *Phyllosticta cycadina* in culture. Cultures started from the ascospores developed pycnidia of *Phyllosticta* in about 15-20 days. They also developed perithecia of *T. indica* after 2 months.

The results of artificial inoculations have been summarized in Table I.

TABLE I

Showing the percentage of infection of Cycas revoluta *leaflets under different conditions*

	Sources of inoculum	Percentage of infection
1	Culture obtained from infected leaves	85
2	do. pycnospores ..	90
3	do. ascospores ..	55
4	Spraying germinated pycnospores ..	70
5	do. ascospores ..	No infection

Table I clearly shows that ascospores were non-pathogenic, whereas pycnospores caused infection to about 70% leaflets. Culture obtained from ascospores was also comparatively less effective than the cultures derived from pycnospores or infected leaves of *Cycas revoluta*.

Experiments on spore germination showed that some of the ascospores started producing the germtube within 6 hours. Over 90% spores germinated between 12 and 13 hours. 100% germination was not attained even after 20 hours. It was observed that practically all the cells of the ascospores were capable of producing the germtube (*vide* Fig. 1). Some of the mature ascospores germinated even within the ascus. The germtube of such ascospores emerged by piercing the wall of the ascus.

Species of *Phyllosticta* have been reported to have their relationship with several ascomycetous fungi, *viz.*, *Mycosphærella*,[9] *Venturia*,[8] *Guignardia*,[3] *Leptosphæria*[2] *and Pleosphærulina*,[1] etc. So far no species of *Phyllosticta* has been found to be associated with *Teichospora*. Fischer[4] found *Teichospora salicina* in close association with a species of *Chætophoma* in Australia. Gäumann

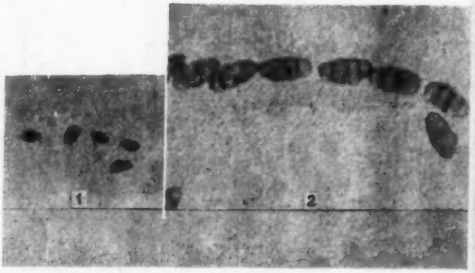

FIG. 1. Showing the formation of germtubes from different cells of the ascospores, × 347.

FIG. 2. Showing the germinating ascospores within the ascus, × 740.

and Dodge[5] reported that all possible imperfect forms have been ascribed to the genus *Teichospora* without their appropriateness being culturally determined. In the present investigations it was found that the isolated ascospores of *T. indica* invariably yielded the culture of *Phyllosticta cycadina* on a medium which was prepared with dead leaves of *Cycas revoluta*. It also established that the leaflets of *Cycas revoluta* sprayed with the spores of *P. cycadina* or inoculated with its culture frequently developed the perithecia of *T. indica* when placed under perfectly sterilized conditions. Morphological characters of *P. cycadina* and *T. indica* showed resemblance. The thickness of the hyphæ and the distance in their septation was almost similar. It is, therefore, concluded that *Teichospora indica* is the ascigerous stage of *Phyllosticta cycadina*.

Dept. of Botany, R. N. TANDON.
University of Allahabad, K. S. BILGRAMI.
February 22, 1960.

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* Abstracts consulted from *Review of Applied Mycology*.

CHROMOSOME NUMBERS IN SOME SPECIES OF *VICIA*

CYTOLOGY of genus *Vicia* has been worked out by a large number of workers[1] (Heitz, Swes-chinkova, Hirayoshi, Mc Leash, etc.) and more specially of *Vicia faba* due to its low chromo-some number and bigger size of chromosome.

The acetocarmine preparations of the pollen mother cells of five European varieties of *Vicia faba* and six other species of *Vicia* were made to study the chromosome numbers and the results obtained are given in Table I.

TABLE I

	Name of the plant	2 *n* as reported by previous workers	2*n* as reported by the present author
1	*Vicia faba*	12 (Hirayoshi. 1952) (McLeash, 1953)	..
2	*Vicia faba* var. *minor*	..	12
3	var. *aroma*	..	12
4	var. *aroma* white	..	12
5	var. *morogena*	..	12
6	var. *oderus*	..	12
7	*Vicia monantha*	14 (Heitz, 1931)	14
8	*Vicia narbonensis*	14 do.	14
9	*Vicia ervilia*	14 do.	14
10	*Vicia grandiflora*	14 do.	14
11*	*Vicia onbrychordes*	..	12
12*	*Vicia sepinum*	..	12

* New Report.

McLeash (1953) has reported 2 *n* : 12 in *V. faba* but Hirayoshi (1952) found 2 *n* : 12 in European strains and 2 *n* : 14 in Asiatic strains. The present material received from European region indicates the chromosome number to be 2 *n* : 12 which confirms Hirayoshi's findings for European species.

The chromosome numbers of *Vicia onbry-chordes* and *Vicia sepinum* are 2 *n* : 12. The numbers are being reported for the first time as known to the author.

Thanks are due to the Director, Royal Botanical Gardens, Argotti, Malta, who very kindly supplied the seeds, to Dr. H. N. Mehrotra, Professor of Botany, for help in the preparation of this note and to Dr. A. Rathore, Principal, for the encouragement and laboratory facilities.

Dept. of Agri. Botany, SUDHIR KUMAR.
Rajasthan College of Agriculture,
Udaipur, *January* 11, 1960.

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OLPIDIUM UREDINIS PARASITIC WITHIN THE UREDIOSPORE OF *UROMYCES LEPTODERMUS* SYD.

Olpidium uredinis (Lagerh.) Fischer is known to be hyperparasitic within the urediospores of rusts. It was first found within the urediospores of *Puccinia airæ*, *P. violæ*, *P. rahmni* in Germany by Lagerheim[2] (1888) and then subsequently reported on *P. coronata* and *P. levis* (Arthur,[1] 1929) from U.S.A. Since then, no other host genus for this hyperparasite was reported until in 1942 Thirumalachar reported it parasitic within the urediospores of *Hemileia canthii* Berk and Broome a rust on *Canthium parviflorum*. This was the first time it has been reported in India.

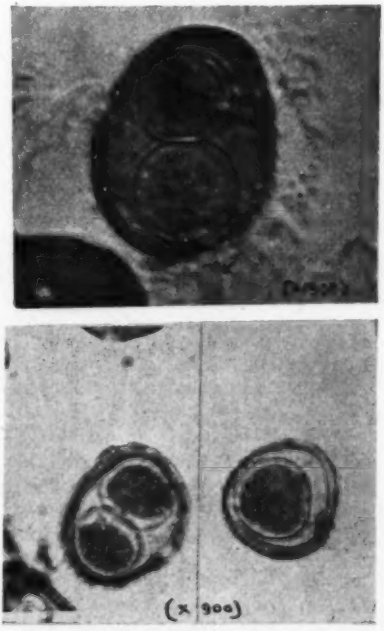

FIG. 1. Sporangia of *Olpidium uredinis* within uredio-spores of *Uromyces leptodermus* Syd.

During the studies on urediospores and teliospores of *Uromyces leptodermus* Syd. on *Setaria verticillata* in Poona, the author observed *Olpidium uredinis* hyperparasitic within the urediospores. Review of literature indicated

that there were no records of *Olpidium uredinis* parasitizing any of the species of *Uromyces* and hence this is a new record of host substratum for *Olpidium uredinis*.

The sporangia are single celled, predominately spherical or ellipsoidal, not entirely filling the urediospore. They are smaller when there are more than one within the urediospores; which, in some cases, are up to five in number. The wall of the mature sporangium is smooth, delicate and hyaline, forming a short discharge tube which pierces the wall of the urediospore, the tip at least being extramatrical. Well-marked discharge tubes were observed in quite a few urediospores.

Resting spores could not be observed. The affected urediospores were without any cell contents and non-viable.

The author is grateful to Dr. M. J. Thirumalachar for suggestions and to Dr. S. P. Agharkar, Director, M.A.C.S., for affording facilities for work.

M.A.C.S. Laboratory, Law College Buildings, Poona-4, *May* 4, 1959. B. V. PATIL.

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LIFE-HISTORY OF *EUPROCTIS HOWRA* MOORE (LEPIDOPTERA—LYMANTRIIDAE), A PEST ON COFFEE

SEVERAL species of Lepidoptera infest various species of coffee. The damages they bring about are mainly through defoliation, or boring in the plant or cutting the tender stems of seedlings. *Euproctis howra* Moore, a pest species whose life-history is briefly dealt with here, was noticed causing appreciable defoliation of Arabica coffee, *Coffea arabica* L., at the Coffee Research Station, Balehonnur. Earlier records on the biology of this species are apparently lacking in the literature though related species of the genus have received wide attention due to their economic importance.[1-3]

The activity of the species was perceptible during March 1958 and 1959 and extended for three to four months thereafter. This presented opportunities to conduct life-history studies in the laboratory. The pest stages were reared in petri-dishes 4" × ¾". Temperature and relative humidity were daily recorded during the period of study.

LIFE-HISTORY

Moths of *E. howra* are yellowish with a wing expanse of about 2 cm. In the laboratory, oviposition commenced a day after emergence. A female was found capable of laying an average of 125 eggs in her lifetime which averaged 6·7 days.

The eggs are pale-yellow in colour, relatively smooth-surfaced and measure 1 mm. in diameter. They are laid in masses on the leaves and are covered with pale-brown hairs. The egg stage lasted on an average 7·2 days.

There are seven larval instars. Each body segment of the larva possesses branched setæ disposed in eight verrucæ. The crochets are uniordinal arranged in homoideous mesoseries. Abdominal segments 6 and 7 have eversible glands dorsally.

The first instar larva measures 2 mm. × ½ mm. and has a brown head and yellowish-white body. Body colouration, however, changes during the course of subsequent instars. Thus, in the second instar, the colour of the first two abdominal segments turns black dorsally and laterally

TABLE I

Life-history of Euproctis howra

Stage	Cases	Average			Range		
		Duration (days)	Temp. °C.	Relative Humidity	Duration (days)	Temp. °C.	Relative Humidity
Egg ..	14	7·2	26·6	48·0	6-8	25·8-27·8	35·5-59·6
Larva 1st Instar	10	16·5	25·9	53·5	16-18	24·9-27·9	42·7-73·7
2nd ,, ..	12	8·5	26·5	60·5	6-10	25·9-27·1	57·5-72·5
3rd ,, ..	11	7·5	27·0	62·5	6-9	26·2-28·4	59·8-72·7
4th ,, ..	13	7·0	26·4	64·1	6-9	25·0-28·4	56·3-78·5
5th ,, ..	9	10·0	25·6	70·2	8-11	23·3-27·8	66·6-81·5
6th ,, ..	9	9·0	25·5	71·0	5-13	23·3-27·8	66·6-83·5
7th ,, ..	10	10·0	25·7	75·3	5-15	24·8-27·1	73·1-83·5
Pupa ..	15	14·6	26·9	75·3	13-19	24·7-27·9	69·6-83·1
Adult ..	12	6·7	25·7	76·0	6-8	24·2-27·9	75·3-85·0

and this remains prominent till the last instar. In the third instar, a crimson colouration on the dorsal and lateral regions of the thoracic segments, two and three, and the abdominal segments, three to six, becomes apparent. Gradually, this colouration becomes interspersed with black shades leaving only two yellow bands at the outer dorsal and lateral margins of the abdominal segments three and six. Full-grown larva measures 14 × 3 mm. The larval stage took an average of 68·5 days.

Pupation takes place in a silken web spun by the final instar larva. The pupa is pale-brown in colour and measures 10-12 mm. in length. Cannibalism among larvæ was commonly observed at the period just prior to pupation. Often the free larvæ preyed upon others that had pupated or were in the process of pupation. The pupal stage averaged 14·6 days. Table I gives the details of duration of each stage in the life-history in relation to temperature and relative humidity.

Sincere thanks are due to Dr. B. T. Narayanan, ex-Director of Research, Coffee Research Station, Balehonnur, for his keen interest in the studies.

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CHROMOSOME NUMBER OF SOME HIMALAYAN POLYTRICHACEAE

IN two recent notes Khanna[1,2] published the chromosome number in forty-six species of Himalayan mosses belonging to nine families, mainly Pottiaceæ and Dicranaceæ. The present communication lists the chromosome number in 17 taxa of Polytrichaceæ.

Capsules of the various species were fixed in acetic alcohol (1 : 3) from the plants growing at Darjeeling and its suburbs (Eastern Himalayas, 6–12,000 ft.). The chromosome numbers were determined from acetocarmine squashes of the spore mother cells. The observations are summarized in Table I.

There appears to be a strict consistency of the base number of chromosomes in this family in strong contrast to what is known in other families. A detailed account will appear elsewhere.

TABLE I

	Name of the species	Number of bivalents
1*	*Lyellia crispa* R. Br.	7 ca
2	*Atrichum pallidum* Ren. & Card.	7
3	*Oligotrichum semilamellatum* (Hook. fil.) Mitt.	7
4	*Polytrichum alpinum* Hedw.	7
5*	*P. himalayanum* Mitt.	7
6	*P. perichætiale* Mont.	7
7*	*P. leucopogon* Ren. & Card.	7
8	*P. aloides* Hedw.	7
9	*P. stevensii* Ren. & Card.	7
10*	*P. neesii* C. Mull.	7
11*	*P. junghunianum* Dozy et Molk.	7
12	*P. microstomum* R. Br.	14
13*	*P. Teysmannianum* Dozy et Molk	7
14*	*P. Teysmannianum* Dozy et Molk. var. *Darjeelingensis* var. nov.	7
15*	*P. fastigeatum* Mitt,	7
16*	*P. nudiusculum* Mitt.	7
17*	*P. proliferum* Griff.	7

Chromosome number for the species marked with asterisk is being reported for the first time.

The writer is deeply indebted to Prof. P. N. Mehra, Shri. R. S. Chopra and Dr. T. N. Khoshoo for valuable criticism and useful suggestions and to Mr. A. H. Norkett of the British Museum, London, for helping with the identification of the specimens.

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CHROMOSOME NUMBER IN *LEUCAS ASPERA* SPRENG

CYTOLOGICAL studies of *Leucas aspera* Spreng (commonly known as Swetdron), collected from the fields of Muzaffarpur, have been made. This species is found growing wild in the cultivated fields and is of much medicinal importance.

For meiotic studies the flower-buds were fixed in 1 : 3 acetic alcohol. Squash preparations of the anthers were made following the usual acetocarmine technique. Camera lucida drawings were taken from the temporary slides.

The pollen mother cells at diakinesis and metaphase I showed eleven bivalents (Fig. 1). The distribution of chromosomes at all the stages was normal. The disjunction of chromosomes at anaphase I and II was normal, eleven chromosomes being clearly visible at either pole (Fig. 2). These studies indicated that eleven is the haploid chromosome complement of the

species and that the plant is a diploid one with $2n = 22$.

Fig. 1

Fig. 2

FIG. 1. Camera lucida drawing of Metaphase I showing eleven bivalents.

FIG. 2. Camera lucida drawing of Telophase II and Late Anaphase II showing regular disjunction.

As far far as the authors are aware, the chromosome number of *Leucas aspera* Spreng has not been reported as yet. The authors' observations clearly indicate eleven to be the haploid number of the plant. Thus the genus seems to be allied to Salvia, Phlomis, Ballota and Cycopus as only they have got the same haploid number in the whole of the family Labiatæ, reported so far. It may be noted here that 5 is the lowest and 19 is the highest basic chromosome number so far encountered in the family Labiatæ.

The authors are grateful to the Head of the Department of Botany for providing necessary facilities.

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CHROMOSOME NUMBERS OF A FEW COMMON DICOTYLEDONOUS PLANTS

REFERENCE to the available literature[1-5] shows that the chromosome numbers of the undermentioned plants have not been recorded before.

TABLE I

Sl. No.	Name of plants	Family	Chromosome numbers	
			n	2*n*
1	*Glycosmis pentaphylla* Corr.	Rutaceæ	9	18
2	*Ravenia spectabilis* Engl. = (*Lemonia spectabilis* Lindl.)	do.	..	36
3	*Turnera ulmifolia* Linn.	Turneraceæ	15	30
4	*Wedelia calendulacea* Less	Compositæ	25	50

It is interesting to note that *Glycosmis pentaphylla* Corr. and *Ravenia spectabilis* Engl. (= *Lemonia spectabilis* Lindl.) which come under the tribe Aurantieæ (Hooker, 1885) show difference in number. Nine appears to be the basic number in the above-mentioned tribe, as it has been reported for a large number of plants in the family Rutaceæ. On this basis, *Ravenia spectabilis* Engl. could be considered as a Tetraploid.

Wedelia calendulacea Less, shows variability in number during somatic and meiotic mitosis. No such irregularity has, however, been noted in *Turnera ulmifolia* Linn., which is the only plant available under Turneraceæ in this locality.

Detailed studies of the cytology and embryology of the above-mentioned plants are in progress.

My thanks are due to the Ministry of Education, Government of India, for the award of a Senior Scientific Research Training Scholarship.

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EFFECT OF SOME SURGICAL EXCISIONS ON THE REGENERATION OF THE ROOT APEX OF *SORGHUM VULGARE* PERS.

STUDIES in recent years by Clowes (1956, 1958 *a* & *b*, 1959) have brought out the inadequacy of limiting the investigations on root apices to the structural configuration in explaining their organization. He has emphasized in this connection the importance of studying the cytophysiological state of the cells. In 1956 he, on the latter basis, postulated the presence of a quiescent centre at the apex of the root body (*i.e.*, not including the root-cap).

While studying the apical organization of the roots of *Sorghum*, we find the structural configuration to be of three discrete histogens, an independent initial zone each for the plerome and root-cap and a common zone for the dermatogen and periblem, called the protoderm-periblem complex (Fig. 1). In addition to this

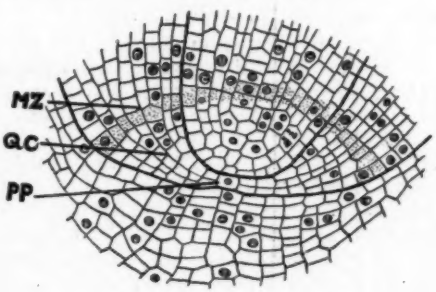


FIG. 1. *Sorghum vulgare*. Median longisection of the root apex showing its organization from the structural and cytophysiological points of view. P.P.—Protoderm-periblem complex; Q.C.—Quiescent centre; M.Z.—Meristematic zone. The stippled region is the outer limit of the quiescent centre (Diagrammatic).

we are able to distinguish at the extreme tip of the root body a group of cells, which are not deeply stained, have vacuoles, smaller nuclei and nucleoli, lesser nucleolus/nucleus and nucleus/cell ratios and lesser proportion of dividing cells (Table I) when compared with the cells just behind it. Thus, the group of cells at the extreme tip appears to be not as active as the cells surrounding them in the form of an arch on the side of the root body as seen in longisection. This group of cells which are in a state of repose constitutes the quiescent centre. The active zone behind it appears to be the actual site of meristematic activity which has

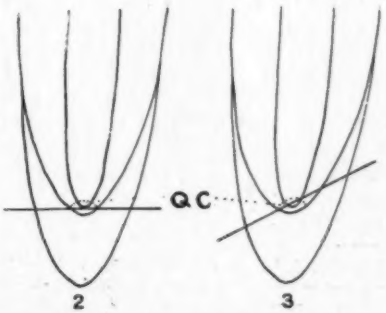
TABLE I

Sorghum vulgare. *The areas of the cell, nucleus and nucleolus of the quiescent centre and meristematic zone (mean of 20), the nucleolus/nucleus and nucleus/cell ratios and the number and proportion of dividing cells in the two regions*

	Quiescent centre	Meristematic zone
Area of cell (sq. μ)	67·92 ±19·61	76·11 ±33·77
,, nucleus ,,	15·687 ±5·587	19·872 ±6·424
,, nucleolus ,,	0·6830 ±0·1650	2·2584 ±0·6673
Nucleolus/nucleus %	4·35	11·36
Nucleus/cell %	23·09	26·10
Total No. of dividing cells (average of 5 counts)	46·0	220·1
No. of dividing cells (average of 5 counts)	5·8	80·2
Percentage of dividing cells	12·12	37·04

been tentatively named here as the *meristematic zone*.

With a view to determining the role of the quiescent centre in the regeneration of the root apex, the stilt roots of this plant were excised (1) *transversely*, the cut passing through the quiescent centre excising away part of it and the root-cap in front (Fig. 2), and (2) *obliquely*, part of the quiescent centre and root-cap being cut away (Fig. 3). The cut surfaces were



FIGS. 2-3. Showing the transverse and oblique surgical excisions given to root apices. Q.C.—Quiescent centre.

smeared with lanolin and the roots allowed to grow. After a fortnight the apices were processed and the sections examined.

Plate I shows the median longisection of a root given the transverse cut. The cells of the

quiescent centre (Q.C. in plate) have not regenerated and there appears to develop a thickly staining callus-like tissue. Further growth is brought about by the cells on both flanks of the quiescent centre.

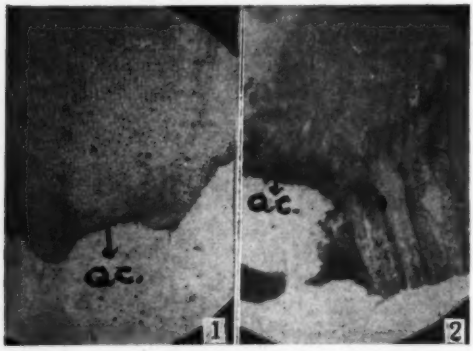


PLATE I. *Sorghum vulgare.* The root apex excised transversely. The cells of the quiescent centre (Q.C.) do not regenerate and instead develop thick walls. Note the regeneration on both flanks of the quiescent centre.

PLATE II. *Sorghum vulgare.* The root apex excised obliquely. Note the callus-like development at the quiescent centre (Q.C.) and a lateral root developing to one flank.

Plate II is the median longisection passing through one half of the root-tip given the oblique cut. Here also the cells of the quiescent centre are found not to take any part in the regeneration of the root and have developed into a thickly staining callus-like tissue (Q.C. in plate). To one side there develops a lateral root.

These two surgical experiments show that once the cells of the root apex go into quiescence, they do not take any active part in the regeneration and reorganization of the root.

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MEIOSIS IN POLLEN STERILE AND POLLEN FERTILE VARIETIES OF COCONUT

VARYING degrees of pollen sterility have been reported by several workers in varieties of *Cocos nucifera* L.[1] Patel[2] found about 25% of sterile pollen grains in six trees, while Aldaba[3] observed 3 to 33% sterility in some varieties in the Philippines. The reasons for the incidence of such sterility are not clear and cytological studies in this economically very important plant have been few. Sharma and Sarkar[4] found during a study of meiosis in microsporocytes in a variety of coconut that while sixteen bivalents were formed at metaphase I, chromosome disjunction was irregular leading to unequal distribution of chromosomes at metaphase II. Also, hexads occurred at the sporad stage besides normal tetrads. In order to ascertain the reasons for the incidence of high pollen sterility in some coconut trees, meiosis was studied by us in three varieties. Apricot from Straits Settlement, Dwarf Red and Laccadive Ordinary. Apricot and Dwarf Red had on an average 30% pollen sterility as measured by stainability in acetocarmine and Laccadive Ordinary about 5% sterile grains. The pollen fertility data were collected during a period of two years and this trend was consistent, though there was some variation between inflorescences of the same tree.

Meiosis was regular in Laccadive Ordinary with 16 bivalents at diakinesis and metaphase I (Fig. 1). Two bivalents were associated with the nucleolus at diakinesis and one bivalent was markedly larger than the rest. Microspore tetrads were generally tetrahedral, though isobilateral and T-shaped tetrads also occurred occasionally. In Dwarf Red and Apricot, on the other hand, several abnormalities were observed. There was a slight reduction in the frequency of chiasmata per bivalent (Table I). One

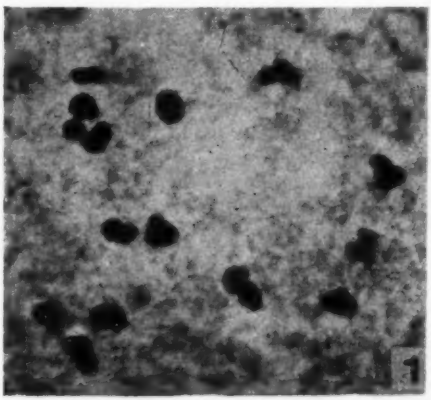
TABLE I

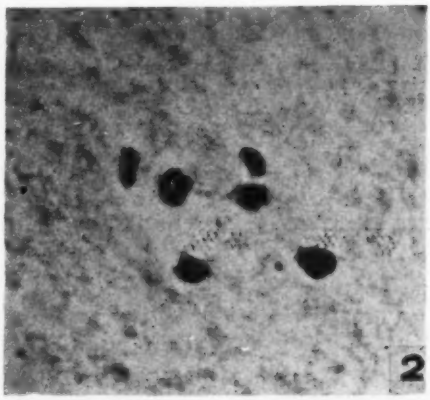
Chromosome associations during meiosis in three varieties of coconut

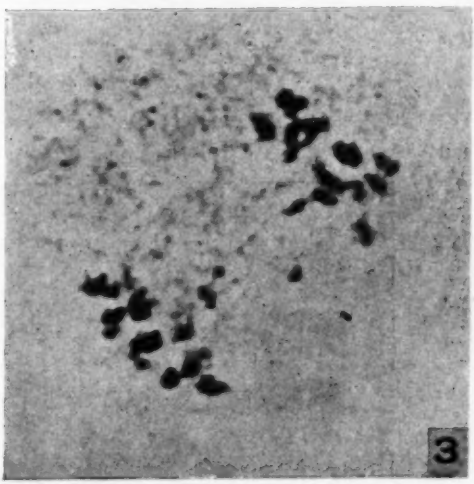
Variety and Tree No.	No. of P.M.Cs. studied	Mean frequency per cell			Mean No. of chiasmata	
		Quadrivalent	Bivalent	Univalent	Per cell	Per bivalent
Apricot (XI/62)	49	0·041	15·918	..	26·5	1·74
Dwarf Red (XI/73)	54	0·019	15·962	..	29·3	1·84
Laccadive Ordinary (XI/27)	51	..	16·00	..	30·57	1·91

quadrivalent occurred in two cells in Apricot and in one cell in Dwarf Red. Two cells with 6 bivalents (Fig. 2), one cell with 8 bivalents,

one cell with 10 bivalents and one cell with 14 bivalents were found in Apricot at metaphase I, in addition to cells with the regular 16 bivalents. Such 'chromosome mosaics' probably arise from abnormalities during premeiotic mitosis. Another interesting feature of meiosis in this variety was the persistence of the nucleolus beyond prophase (Fig. 4). In both Dwarf Red and Apricot, dicentric bridges and acentric fragments occurred at anaphase I, thus indicating heterozygosity for inversions (Fig. 3). Irregular disjunction, formation of micronuclei and the occurrence of monads, pentads, hexads and octads were the other abnormalities observed in these two varieties. The percentage of aberrant sporads was 8 and 26·2 in Dwarf Red and Apricot respectively. In Laccadive Ordinary, one pentad was observed among 123 sporads examined.







FIGS. 1–4. Meiosis in the variety Apricot. Fig. 1. Metaphase I showing 16 bivalents. Fig. 2. A cell at Metaphase I with 6 bivalents. Fig. 3. Anaphase I with a dicentric bridge and an acentric fragment. Fig. 4. A cell at Metaphase I with a persistent nucleolus.

From these data, it is obvious that the pollen sterility observed in Dwarf Red and Apricot is caused by an irregular meiosis. But what causes the aberrant meiotic behaviour can only remain conjectural pending further studies. Both these varieties possess dwarf characteristics. In this connection, it is interesting that, according to Jack and Sands[5] and Patel,[2] self-pollination is possible to a greater extent in dwarf varieties due to the overlapping of the female and male phases in the same inflores-

cence. It is hence probable that inbreeding is the cause of the various meiotic abnormalities and the consequent pollen abortion observed in many dwarfs, since it is now well known that inbreeding in a normally cross-fertilised plant has important cytological repercussions. No generalisation can, however, be made, as far as coconut is concerned, until more extensive studies are undertaken in a large number of tall and dwarf varieties. Such studies seem well worthwhile since if any relationship between the extent of self-fertilisation and the incidence of pollen sterility can be established, pollen sterility data could furnish an approximate estimate of the frequency of self-fertilisation in different varieties.

One of us (M. C. Nambiar) is indebted to the Indian Central Coconut Committee and the Joint Director, Central Coconut Research Institute, Kasaragod, for deputing him to the I.A.R.I., where this study was carried out and for providing the material used in this study. We are grateful to Dr. B. P. Pal and Dr. A. B. Joshi for their interest in this study.

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THE OCCURRENCE OF ROOT-KNOT NEMATODES ON SUGARCANE AND ON SOME WEEDS

NEMATODES are among the serious parasites of sugarcane. Fielding and Hallis[1] listed 11 species of nematodes as parasitizing the plants in U.S.A. and other countries. Birchfield and Martin[2] studied a species of *Tylenchorhynchus* feeding on the roots of sugarcane. Srinivasan[3] from India reported a *Pythium*-nematode complex causing chlorosis of sugarcane in the neighbourhood of Coimbatore and in Tiruchirapally District of Madras State. Jensen *et al.*[4] reported eight genera of plant parasitic nematodes found in association with sugarcane in Hawaii, of which three causing root-knot, root-lesion, and root-spiral were considered to be of particular importance.

During January-February 1958 a severe chlorosis of sugarcane crops was reported from the Nellikuppam Sugar Factory area of Madras State. The disease was characterized by chlorosis of the leaves in the form of yellow stripes along their length. Older leaves were normal but the younger ones showed the chlorotic symptoms. The plants were stunted and presented an unhealthy appearance even from a distance. Crops of all ages were affected but the symptoms were prominent on crops over six months old. The disease was observed on the varieties Co. 449, Co. 527 and Co. 658 during 1958 and 1959. Though the disease was observed more commonly during the cooler months, it was also found in a less severe form during summer months.

The roots of the affected plants were dug out and examined carefully. Of the two kinds of roots normally found in cane plants, the wiry roots were apparently less affected, whereas the thick-white roots showed symptoms of swelling and knotting. The swellings were linear but mostly towards the tips of roots and the knots were half to two-thirds of a cm. in thickness. Up to 50% of the thick-white roots in a plant were found affected (Fig. 1).

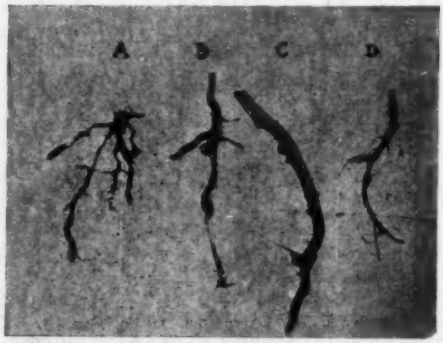

FIG. 1. Root-knots caused by nematodes on (A) Sugarcane; (B) *Acalypha indica*; (C) *Cleome viscosa*, and (D) *Gynandropsis pentaphylla*.

When the roots were examined microscopically the association of two types of nematodes with the roots was observed. One type of nematode, whose males were predominant, measuring 352–446 μ in length, 18–29 μ in width at the thickest point, the œsophagus 105–131 μ and the tail 30–35 μ, was found mainly on the surface of both the types of roots and in the soil. The other nematode was found mainly inside the tissues of knotted roots and both the males and

females were equally common. The females measured 400–460 μ in length, 45–50 μ in width at the thickest point, œsophagus 40–45 μ and the tail 30–35 mμ, the males measured 420–460 μ in length, 20–25 μ in width at the thickest point, œsophagus 55–60 μ and the tail 30–35 μ and the cyst was pear-shaped measuring 600–650 × 380–400 μ, with a prominent beak. Franklin[5] has tentatively identified the former as a species of *Tylenchorhynchus* and the latter as *Meloidogyne javanica* (Treub) Chitwood. Further examinations by plating the affected roots, after surface sterilization, in nutrient agar media showed that no fungus or bacterium was associated with the disease.

The nematodes were separated by the Baermann Funnel Technique and attempts were made to multiply them in agar cultures. The *Tylenchorhynchus* sp. could be easily isolated and cultured in oat meal agar medium, whereas *M. javanica* failed to multiply in the medium.

Subsequent observations revealed that the same two types of nematodes were associated with some of the common weeds in and around sugarcane fields in the tract. *Acalypha indica* L., *Gynandropsis pentaphylla* D. C. Prodr. and *Cleome viscosa* L. were examined and found affected (Fig. 1). The chief symptoms of infection were chlorosis of the leaves, stunting of the plants, and severe knotting of the roots. Each of these hosts were examined and the nematodes separated and identified.

In order to establish the pathogenicity of *M. javanica* knotted roots were collected fresh from the fields, washed thoroughly in running water and then in changes of distilled and sterile-distilled water, macerated in a waring blender for one minute and the nematode suspension thus obtained inoculated on healthy potted plants. Two sets of inoculations were made on sugarcane (variety Co. 658) and *A. indica* plants, grown both in unsterilized and sterilized soils for the purpose. The nematode suspension in water was either poured into the soil before planting or poured around the potted plants so as to drench the soil around. Four to eight pots with four plants each were used for each set of inoculations. In all these inoculations 100% infections were obtained, the symptoms of infection in the form of knotted or swollen roots appearing within 40 to 45 days after inoculation. The nematode isolated from sugarcane was infective on sugarcane and *A. indica* and the isolate from *A. indica* was infective on both the hosts. The affected roots were examined and *M. javanica* was recovered from each case. When the nematode suspensions were added to both sterilized and unsterilized soils in pots they could not be recovered after a fortnight, thereby indicating that they could not survive as saprophytes in soil.

Both *M. javanica* and *Tylenchorhynchus* sp. reported here are distinct in several respects and differ from *Radopholus similis* (Cobb.) Thorne reported by Srinivasan[3] in their size and pathogenicity. *R. similis* was reported to cause chlorosis in association with *Fusarium* sp. and *Pythium* sp., whereas in the present studies no fungus or bacterium was found involved. Species of *Meloidogyne* are known to be obligate parasites and are reported on a wide range of hosts but species of *Tylenchorhynchus* are mainly saprophytes.[1,2,6,7] In the present investigations the pathogenicity of *M. javanica* on sugarcane as well as on *A. indica* has been established and also its obligate nature indicated. It is also evident that the weeds play an important role in the transmission of the disease. Further studies on the interrelationships of the nematodes in causing damage to the plants are in progress.

We are thankful to Messrs East India Distilleries and Sugar Factories Ltd., Nellikuppam, for their co-operation in investigating the disease.

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INHERITANCE OF LEAF IN PIGEON-PEA—*CAJANUS CAJAN* (L.) MILLSP.

IN pigeon-pea—*Cajanus cajan* (L.) Millsp., inheritance of flower colour, pod colour and seed-coat colour has been studied by Menezes (1956) and Dave (1934) and inheritance of habit, inflorescence, flower, seed, stature and wilt resistance has been reported by Pal (1934) and Shaw (1936 *a*, *b*).

Studies on F 1 behaviour of the intervarietal crosses in this crop with reference to inheritance of two mutated characters, *viz.*, unifoliate condition of leaf and roundish leaf apex have been reported by Joglekar and Deshmukh elsewhere (1959). In the present paper observations on inheritance of above characters have been given in brief.

In the year 1957-58, the writers made crosses with the object of studying the inheritance of the leaf characters and secured hybrid seeds using the two mutants, *viz.*, *Cajanus cajan* var. *unifoliata* (Leaf—Unifoliate with pointed apex) and *Cajanus cajan* var. *Oval oblong trifoliata* (Leaf-Trifoliate with roundish apex) as reported by Joglekar and Deshmukh (1958) and two improved strains No. 56 and Hyderabad (Leaf—Trifoliate with pointed apex).

The observations on the F 1 and F 2 generation of the intervarietal crosses have been tabulated in Table I.

It is seen from Table I that trifoliate condition of leaf is dominant over unifoliate condition and that it is controlled by one pair of factors as seen from the monohybrid segregation in F 2 (Cross No. 1 & 2, Fig. 1). It is

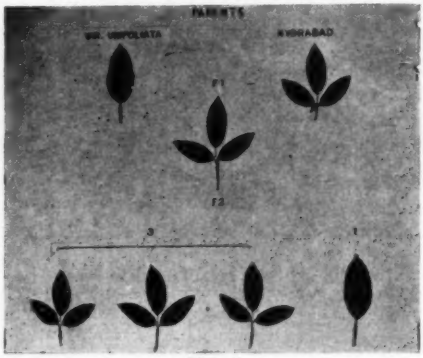

FIG. 1

TABLE I

F1 and F2 observations on the intervarietal crosses in pigeon-pea showing inheritance of leaf characters

Crosses	F 1 Observations	F 2 Segregation				Total X^2	P between
		Observed		Calculated on 3 : 1 basis			
		Trifoliate	Unifoliate	Trifoliate	Unifoliate		
Cross No. 1							
No. 56 (Leaf Trifoliate with pointed apex)	Leaf-Trifoliate with pointed apex	123	35	118·5	30·5	0·692	0·5 & 0·3
Var. *unifoliata* (Leaf-Unifoliate with pointed apex)	..	..	..	..	..	..	..
Cross No. 2							
Var. *unifoliata* × Hyderabad (Leaf—Trifoliate with pointed apex)	do.	224	69	219·75	73·25	0·33	0·7 & 0·5
		Pointed apex	Roundish apex	Pointed apex	Roundish apex		
Cross No. 3							
No. 56 × var. *oval oblong trifoliata* (Leaf—Trifoliate with roundish apex)	do.	354	125	359·25	119·75	0·3010	0·7 & 0·5
Cross No. 4							
Var. *ovaloblong trifoliata* × Hyderabad	do.	104	27	98·25	32·75	1·3309	0·3 & 0·2
		Trifoliate pointed	Trifoliate roundish	Unifoliate pointed	Unifoliate roundish		
Cross No. 5							
Var. *unifoliata* × var. *ovaloblong trifoliata*	do.	277	84	89	24	..	
	Observed Expected on 9 : 3 : 3 : 1 basis	266·65	88·80	88·80	29·62	1·7104	0·7 & 0·5
Cross No. 6							
Var. *ovaloblong trifoliata* × var. *unifoliata*	do.	550	192	194	50	..	
	Observed Expected on 9 : 3 : 3 : 1 basis	554·62	184·88	184·88	61·62	2·95	0·5 & 0·3

also seen that the pointed apex of leaf is dominant over roundish and is also controlled by one pair of factors (Cross No. 3 & 4, Fig. 2).

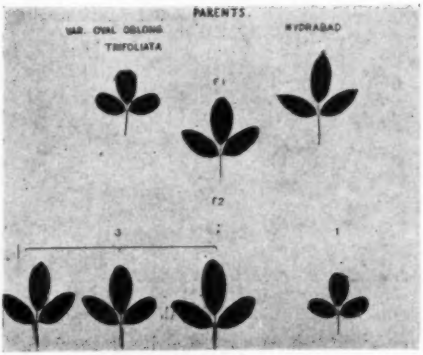

FIG. 2

Observations on cross No. 5 and 6 show that the characters—trifoliate condition and the pointed apex of leaf—are dominant over unifoliate condition and roundish apex and that these two characters segregate on 9 : 3 : 3 : 1 basis (a dihybrid in F 2 (Fig. 3) giving a new double

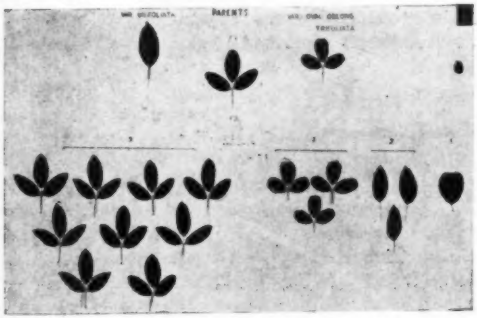

FIG. 3

recessive class of plants with combination of unifoliate condition and roundish apex of leaf.

Agri. Res. Inst., Nagpur,
January 25, 1960.

N. Y. DESHMUKH.
S. S. REKHI.

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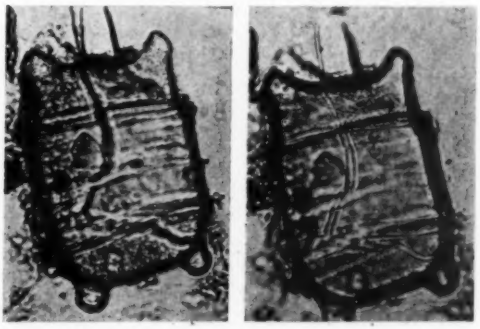
REPORT ON *CERATAULUS TURGIDUS* EHR. FROM INDIAN WATERS

IN the present note *Cerataulus turgidus* Ehr. is reported for the first time from the Indian region, from Chilka Lake in Orissa. The diatom shows the following characters :—

Frustule large and robust ; Valve-face broadly elliptical with two broad truncated processes, situated more or less diagonally and on each side of the valve (Fig. 1). In between the



FIGS. 1–2. Photomicrographs of *Cerataulus turgidus* Ehr. in two optical foci, showing structure and details. Note the bifurcated end of spine in Fig. 2, × 466.

truncated processes, on one side, there are two large spines situated more or less submedially. Similar spines on the corresponding opposite side are not seen. The lateral spines are stout, with the free end distinctly forked (Fig. 2). Girdle face somewhat rectangular and the connecting membrane shows a sigmoid flexure. Length of valve from process to process, 115·5 μ ; length of valve in the middle 75·9 μ ; breadth of valve at process, 62·7–69·2 μ ; length of spine 33·0 μ ; height of process, 13·2–16·5 μ ; breadth of process at tip, 9·9 μ ; areolæ in valve 9 in 10 μ ; areolæ in central zone 12 in 10 μ.

Habitat : Chilka Lake, planktonic, in the outer channel.

Extremely rare, April, 1950.

The type locality of the species is known to be Europe. It is known in the fossil deposits from California and New Jersey. As regards the general distribution, it may be observed that most of the earlier records are from regions north of Tropic of Cancer, the species being known from Monterey, California and Japan Sea in the Pacific, New Jersey, Florida, England, Ireland, Belgium and North Sea Coasts in the Atlantic Ocean. The only earlier record south of Tropic of Cancer and nearer to the Tropic of Capricorn is that from Nguci in South Africa

and East Coast of Madagascar in the Indian Ocean.

Curator, Industrial Section, K. S. SRINIVASAN.
Indian Museum, Calcutta,
January 27, 1960.

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AN EYE DISEASE WHICH CAUSES MORTALITY OF THE FISH *CATLA CATLA* (HAMILTON AND BUCHANAN)

DURING October and November 1959 several unusual cases of fish mortality were reported from different areas in West Bengal. It was found that the damage was due to a new type of eye disease affecting the eyes of catlas. Reports about the disease were received from Barrackpore, Nilganj, Naihati, Chandernagore, Midnapore and Kancharapara. The fish mortality began to occur a few weeks after the unusually heavy rains and floods this year.

The disease observed was found to be specific to *Catla catla*, although other fishes were present in all the tanks studied. Only fishes of lengths varying from 35 to 85 cm. were found to be infected, except in one solitary instance where a small specimen 12·5 cm. in length was affected fatally.

SYMPTOMS

The eyes of the fish are the organs primarily affected by the disease. A series of observations indicated that in the earlier stages, the eye becomes reddish and subsequently the whole of the cornea turns milky white and completely opaque. As the infection advances, the eyeball gets putrefied, leaving behind a punctured cornea or only a hollow eye (Fig. 1). The disease becomes fatal at this stage and by this time the colour of the gills fade. In some specimens secondary bacterial infection of muscles, showing "ecchymoses" (red spots), were also observed at the bases of the caudal and pectoral fins and on the abdomen. The eye infection was not due to either 'Grey Cataract' or 'Worm Cataract'.

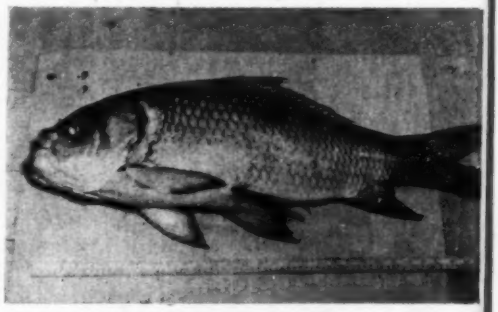

FIG. 1. A catla showing the diseased eye.

The brain of the dead specimens had become "loose" and spongy and it is presumed that the infection of the eye spreads gradually to the brain, thereby killing the fish. Such fatal infections are known in the case of other eye diseases like 'Eye fungus' and 'Worm Cataract'.[1]

Cultures made from the affected regions of the fish showed the presence of one Bacterium and one Actinomycete and further studies are being made to identify the organisms. Considering the symptoms described above, the disease may be either bacterial or virus in origin. So far very little is known regarding the influence of chemical and physical factors of the environment on outbreaks of fish diseases[2] and investigations in this direction are expected to yield interesting results.

Control methods were tried successfully in 5 big fishery tanks. Group treatment only was adopted for economic reasons[3] and the measures were mostly to improve the sanitary and ecological conditions.[2,3] Provision of a high concentration of dissolved oxygen by addition of commercial lime and artificial aeration, removal of decaying matter and disinfection of the water with very dilute potassium permanganate solution (up to 0·5 p.p.m.) were found to be useful in preventing spread of the disease.

Our thanks are due to Dr. B. S. Bhimachar for his kind interest and criticism and to Shri A. K. Banerji for helping in the bacteriological work.

Central Inland Fisheries Research Station, Barrackpore,
November 30, 1959.

V. GOPALAKRISHNAN.
P. D. GUPTA.

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REVIEWS

Principles of Quantum Electrodynamics: Pure and Applied Physics, Vol. 3. By Walter E. Thirring. Translated from German. By J. Bernstein. (Academic Press, Inc., New York), 1958. Pp. 234. Price $ 8.00.

The book under review was first published in German six years ago. The popularity and the praise with which the German edition was received has prompted the publishers to bring the present English translation of it.

Although field theory deals with some of the most fundamental problems of physics, namely, the properties of elementary particles and their interaction with electromagnetic or meson fields it remains to be an area with which most physicists still do not feel at home. The complex mathematical formalism of the subject and its present uncertain state are some of the obstacles that prevent every physicist with familiarising himself with this branch of physics. In this book, the author has made every endeavour to emphasise the physical basis of the theory and to avoid purely mathematical details. Physical concepts such as localizability, measureability, vacuum fluctuations and renormalisation are presented with lucidity.

The book starts with a discussion of the order of magnitude of the effects to be calculated later in detail. Part I of the book besides contains two chapters—one giving a survey of classical electrodynamics, and another in which the Lagrangian formalism for the quantum theory of fields is developed. In Part II of the book the author discusses the quantisation of free fields and the methods of calculating the expectation values of quantum mechanical operators. Part III deals with fields with external sources, and the theory of an electron moving in an electromagnetic field is discussed in great detail. It is here in fact that quantum field theory has its most spectacular success, such as the explanation of the small shift of 1057·2 megacycles between the $2S_{\frac{1}{2}}$ and $2P_{\frac{1}{2}}$ levels of hydrogen (Lamb shift) and the anomalous magnetic moment of the electron of magnitude $e\hbar/2mc \cdot \alpha/2\pi$. These effects are calculated with the aid of a technique known as 'renormalisation' of mass, charge, etc. The theory of interacting fields, scattering processes and the renormalisation theory are all covered in Part V.

The author has confined himself in this book to electrodynamics and thus to aspects of the subject wherein theory has been successful. The reviewer must however confess that in spite of the proclaimed efforts of the author to strip the subject off its mathematical details and to present the physical concepts only, the book is nonetheless not easy to read and is very much condensed. The printing and get-up are of a high order.

V.

Reflex Klystrons. By J. J. Hamilton. (Chapman and Hall, Ltd., London), 1958. Pp. 260. Price 45 *sh.*

Transit time effects and limitations imposed by the electrode structures render conventional electron tubes unserviceable for generation of electromagnetic waves at microwave frequencies. The investigations on the possibility of turning electron transit time effects to profit has resulted in the discovery of the principle of velocity modulation.

Klystrons are tubes in which this principle is utilised for generation of radiations at microwave frequencies. An electron beam, when velocity modulated undergoes what is known as bunching and such bunched electrons add energy to a resonant cavity, as it passes through an interaction gap, provided the phase conditions are right. The reflex klystrons represent a simplified form in which a single cavity serves for modulating the electron beam on its forward journey, as well as extracting energy on its reverse transit, such a reversal being caused by a reflector electrode kept at a negative potential. Because of their inherent simplicity the reflex klystrons have been most popular as C.W. oscillators at microwave frequencies.

These tubes have metallic enclosures and the dimensions of the interaction gap and the cavity and the geometry of the grid structures become very important from the point of tolerance limits. Tuning elements have to be introduced into the tube structure itself and the method of coupling the output power is also through a transmission time which is again a part of the tube structure. The production technology of these tubes therefore has followed a totally different pattern. The matter under review presented in eight chapters covers the fundamental and practical aspects of klystron tubes, providing a fairly complete picture of the subject.

Starting with a small introductory chapter, the

author passes on to the consideration of cavity resonator and output systems with particular reference to klystron design. Chapter 3 deals with electron dynamics of the reflex klystron. Chapter 4 under the title "Load Effects" discusses Ricke diagrams and their application to the particular problem. The fifth chapter under the title "Engineering Aspects" deals with materials of construction and the fabrication aspect. Chapter 6 deals with the characteristics of some reflex klystron in actual use. In Chapter 7 some unconventional reflex klystrons are discussed. The last Chapter 8 indicates future trends.

The book has successfully attempted to integrate all that is known up-to-date about reflex klystrons and will interest tube technologists, microwave engineers and all those who have a general leaning to microwave electronics.

A. J.

Physical Methods of Investigating Textiles. Edited by R. Meredith and J. W. S. Hearle. (Textile Book Publishers Inc., New York), 1959. Pp. viii + 411. Price $ 13.00.

This book, which is the outcome of a course of lectures given at the Manchester College of Science and Technology, contains a happy mixture of both pure and applied research techniques for the study of textile fibres. The techniques described include X-ray methods, infra-red spectroscopy, electron and optical microscopy, methods for the study of mechanical, electrical and optical properties, methods for the measurement of strength, moisture content, frictional properties and so on.

The individual chapters have been written by different authors, most of whom are primarily interested in textiles. However, they have taken the trouble to expound briefly the basic principles of their methods, in addition to describing the practical techniques in detail. The reviewer was particularly impressed by the Chapter on Infra-red Spectroscopy by C. G. Cannon which contains a very concise summary of the results of such studies on the molecular structure of fibres, particularly of the polyamides and the polypeptides. Unfortunately, the very first chapter on X-ray techniques does not come up to the general level, as it completely ignores the more basic studies on the molecular structure of fibres and their results. In fact, nowhere in the book is there a diagram showing the molecular structure of the cellulose chain.

In general, experimental methods are described clearly, with sufficient detail for a physicist to be able to carry out the work himself. Some of these methods, which have been developed in connection with the technology of textile fibres, are likely to find a lot of application in the study of biological fibres in general, and the book will therefore appeal also to research workers interested in the molecular structure of fibres. To the technical physicist, the book will provide a useful reference book, both in giving a short account of the basic principles of his techniques, as well as a concise summary of the available methods.

G. N. R.

Chemical Analysis : Analytical Chemistry of Titanium Metals and Compounds, Vol. 9. By Maurice Codell. (Interscience Publishers, New York-1, N.Y.), 1959. Pp. xiii + 378. Price $ 12.00.

The rapid development of the titanium metal industry during last two decades has necessitated the adoption of standardised, rapid and accurate methods for the analysis of titanium metals and alloys. The book under review covers almost the entire field of the analytical chemistry of titanium and its compounds.

The aim of the book is, as the author puts it, to provide analytical chemists through a single source with all reliable data for analysing any titanium-bearing material.

All the information concerning the analysis of titanium has been collected into a single volume and both published and unpublished information from authoritative sources have been incorporated.

The book is divided into four parts. In part one are given the general procedures adopted in the analysis of titanium and its compounds and in part two are given the methods of estimating the contents of metallic elements like aluminium, vanadium, chromium, etc., in titanium and titanium alloys. Part three deals with the procedure for the estimation of non-metallic elements like hydrogen, carbon, phosphorus, sulphur, etc., in titanium and titanium alloys. Part four deals with the procedures for the analysis of titanium-base materials like titanium-tetrachloride, titanium-pigments, titanium ores and minerals, etc. At the end of the book a very useful list of references is given and also an author index and subject index are provided.

Similar to all Interscience Publications this book also is well produced, attractively bound, and clearly printed.

The book thoroughly merits a place in the libraries of all chemical laboratories. I wish all future publications on analytical chemistry are published on these lines, on element by element or on a group of elements of similar properties.

I warmly commend this book to all students of analytical chemistry and also to experienced analysts.

N. JAYARAMAN.

The Enzymes. Edited by Paul D. Boyer, Henry Lardy and Karl Myrback. Second Edition. (Published by Academic Press Inc., New York, India: Asia Publishing House, Bombay-1), 1959. Pp. xii + 785. Price $ 24.00.

The first volume of the second edition of the now famous treatise on "Enzymes", strikes a departure from the previous edition. In many respects the book bears little resemblance to its predecessor and shows a distinct bias towards kinetics and thermodynamics of enzyme-catalysed reactions.

The first three chapters are concerned with enzyme kinetics. While Segal's article on the development of enzyme kinetics would serve as a good introduction to the subject, the chapter by Hearon and his colleagues is rather abstruse and tends to maintain mathematical rigour at the expense of simplicity of treatment. However, the reviewer feels that this is an unmistakable pointer to the shape of things to come and the research worker in enzymology would do well to master the theoretical concepts so admirably developed in this chapter. Alberty in his article on "the Rate Equation for an Enzyme Reaction", has brought together the pioneering work in this field of his own as well as of others. In the succeeding chapter, Lumry takes up the thermodynamical aspects of enzyme reactions, emphasizing the significant implications to be derived from such a study and some of its important applications.

The next five chapters are devoted to a detailed discussion of the mechanism of enzyme action. In one of these, Gutfreund discusses the mechanism of enzyme-substrate interaction which depends on the geometry of the specific group fitting closely on to the surface of the enzyme. The relation of prosthetic groups to specificity with special reference to the heme enzymes and the DPN-linked dehydrogenases are given detailed consideration. The principles of specific structural effects due to enzyme-boenzyme-substrate compound formation and the effect of charged or dipolar groups in the neighbourhood of the active site are further discussed by Westheimer in his review on Enzyme Models and by Koshland Jr. in his article on Group Transfer Enzymes. The physico-chemical aspects of electron transport in biological oxidation and the kinetic evidence available to-date on Reaction Pathways and the problem of oxidation of ferrohemoproteins by oxygen are ably summarized by George and Griffith. Williams in his article on co-ordination, chelation and catalysis gives an authoritative summary of the present status of our knowledge on metal chelates which could serve as models for metallo-enzymes. The spectra, magnetic moments and red-ox potentials of metal complexes are described and the catalytic power of such complexes in red-ox reactions critically examined.

This is followed by an incisive and thought-provoking article by the late Prof. Linderstrom-Lang and Schellman on protein structure and its relation to enzyme activity and specificity in which they discuss the manner in which the different possible conformations of the peptide chains in enzyme proteins can lead to an assembly of groups with catalytic activity and the factors which may enhance or inhibit the formation of such sites.

The reactive groups of enzymes are considered in the next two chapters. Boyer contributes a masterly review on the sulphydryl and disulfide groups of enzymes while the other reactive groups are dealt with by Fraenkel-Conrat. Boyer has given in his article an exhaustive list of enzymes tested for the presence of sulphydryl groups.

The last two chapters, one on "Induced Formation of Enzymes" by Pollock and the other on "The Control of Enzyme Activity" by Pardee deserve special mention for their lucidity of presentation. Pollock has given satisfactory evidence to show that enzyme induction does involve the synthesis on the enzyme as opposed to its activation.

The present volume bears testimony to the phenomenal advances made in the elucidation of the mechanism of enzyme action and the wealth of information that has accumulated during the past decade about enzyme action on a molecular level. Its freshness of approach and its high standards of accuracy and clarity are outstanding and the editors are to be congratulated for the commendable work they have done in organizing this volume. The publishers have also made an equally commendable effort since the printing is excellent and no misprints are discernible in 785 pages of this volume.

P. S. SARMA.

Illustrated Genera of Rust Fungi. By George B. Cummins. (Burgess Publishing Company, Minneapolis 15, Minnesota), 1959. Pp. 131. Price $ 4.50.

In this illustrated manual of the rust fungi (Uredinales), Dr. Cummins has brought together the salient features of the ninety-five genera of this group recognized by him from amongst the one hundred and forty or more names known. The original citation, a clear and concise description, and the name of the type species are given for each genus, together with short taxonomic notes and brief notes on host range, geographic distribution and references to recent and important taxonomic literature. Excellent line drawings and photographs are provided to indicate the characteristics of every genus. There is an introduction dealing with spore forms of the rust fungi, form genera, life-cycles, concept of correlated species, host-parasite relationships and taxonomic problems in the rust fungi. There is also a list of synonyms which shows that forty-five names are regarded as synonyms of other rust genera by the author. This list of synonyms includes some genera described from India: *Acervulopsora* Thirum., *Catenulopsora* Mundkur, *Cystopsora* Butler, *Gymnopuccinia* Ramakr., *Hapalophragmiopsis* Thirum., *Kulkarniella* Gokhale and Patel, *Mehtamyces* Mundkur and Thirum., and *Santapauella* Mundkur and Thirum. There is a key to the accepted genera which are arranged in ten sections based on teliospore characters; in the treatment of the genera, the order in the key is followed. A list of general references citing descriptive manuals and regional lists separately, a glossary, and an alphabetical index to the accepted genera are provided.

This manual is a masterpiece of brevity and lucidity. It is simple, but yet authoritative. It is concise, but yet informative. Considering the nature of the information provided and the standard of the illustrations and photographs, it is a brilliant achievement for the author who is one of the leading uredinologists in the world today. Indeed, it is a model manual in every way, and would doubtless inspire specialists in other groups of fungi to aim at the ideal of which it is a worthy example. The student and the teacher, and mycologists and plant pathologists all over the world will find it not only most useful but indispensable especially in the identification of rust fungi. The printing and get-up are excellent.

C. V. SUBRAMANIAN.

Cell, Organism and Milieu. Edited by Dorothea Rudnick. (Ronald Press Co., New York), 1959. Pp. v + 526. Price $ 8.00.

One of the notable activities of the Society for the Study of Development and Growth is the organisation of Symposia on important topics like Development, Differentiation and Morphogenesis. The volume, *Cell, Organism and Milieu*, the latest in the series, embodies contributions made by twelve distinguished investigators at the seventeenth symposium of the Society. These typify how specialists can help in the advancement of knowledge even in a most complex field.

A glance through the contents would suffice to indicate the scope of topics covered and the wealth of scientific information presented. It is not possible to comment on all the chapters, but taken collectively they represent a cross-section of the recent advances made, approaches suggested and techniques developed for a better understanding of the physiology and biochemistry of cells having widely differing origin *vis-a-vis* the changing milieu. Growth and differentiation on one hand, and function and regulation on the other, are indeed the main expressions of the living structure and these have been well brought out in relation to the chemical alterations in the environment.

The volume would surely appeal to a wide range of research workers and the reviewer would recommend it for serious study by advanced students of biology and biochemistry.

J. V. B.

Physiological Studies on the Cotton Crop and their Practical Applications. By Prof. R. H. Dastur. (Scientific Monograph No. 3—Indian Central Cotton Committee), 1959. Pp. 133. Price Rs. 7·00.

The results discussed in the book have come out of research schemes of the I.C.C.C. on the development and physiology of *G. hirsutum* cotton plant as affected by sowing time and application of nutrients to the soil. It is known that sowing time is a very important factor affecting production practically in all crops, and the present investigation on both irrigated and rainfed cotton has brought out the importance of determining and adopting in cultivation practice, the correct time of sowing which will provide the optimum conditions for the vegetative and reproductive phases of the plant at the time one changes to the other. It is also found that this correct time of sowing can vary from tract to tract and from variety to variety.

Information is provided on factors, environmental and nutritional, responsible for the occurrence of red leaf and it cannot be strictly correct to deal with it as a disease inasmuch as it is only a symptom of the nutritional upset. The author for no apparent reason does not mention about the occurrence of red leaf which has no adverse effects on the plant although there have been some papers published on this. One of the chapters in the monograph deals with the effect of synthetic hormones on the cotton plant. Spraying of the plant particularly *desi* cotton, with 10 p.p.m. of the naphthalene acetic acid, increases the yield of the seed cotton by one maund per acre. There is still another chapter dealing with investigations on the failure of Egyptian cotton in the Mysore State where under irrigated conditions in spite of a normal growth the yield of seed cotton is never more than 100-300 lb. per acre. With sowing date and manurial experiments it has been established that application of nitrogen was of no value and has to be supplemented with potash or phosphorus or both.

The author is a distinguished plant physiologist of the country and has been associated with cotton physiological research for nearly 25 years. His work has no doubt produced results of practical value to the cotton farmers in Punjab, Sind, Dharwar and Malwa tracts and a really comprehensive and authoritative book on cotton physiology would have been more appropriate than the present short treatise.

K. R.

The Wealth of India, Industrial Products—Part IV F-H. (Council of Scientific and Industrial Research, New Delhi-1), 1957. Pp. 304.

A review of Part III of this basic and authoritative publication undertaken by the Council of Scientific and Industrial Research appeared in *Current Science*, 1954, 23, 242. The present volume follows the pattern of the previous three volumes and contains articles dealing with 31 industries, arranged alphabetically beginning with Ferro-alloys and ending with Hydroquinone. Each article gives a description of the product, its use, the development of the particular industry and its present position in the country. The principal raw materials, their sources and availability are indicated. In each case the manufacturing process, whether by machinery or as rural and cottage industry, is described with a number of well-printed illustrations. Statistical data in the form of tables and charts add to the value of the information given.

Among the major industries dealt with in this part are Fertilizers (9-38), Film Industry (39-56), Glass (108-37), Gold (159-76), Gur (Jaggery) (182-201), Handloom Industry (206-24), Hides and Skins (225-58) and Hosiery (273-88). The chemical industrial products include Formaldehyde, Furfural, Fusel oil, Glycerine, Hydrogen, Hydrogen peroxide and Hydroquinone.

The volume contains 19 plates and 133 text-figures. Two coloured plates illustrating handloom fabrics from various states are attractive and show the excellence of design and delicacy of work involved in their production.

A "contents" page would have been useful.

A. S. G.

Books Received

Die Evolution Der Angiospermen. By A. Takhtajan. (Veb Gustav Fischer Verlag, Jena, Villengang-2), 1959. Pp. viii + 344. Price 44·90 DM.

Chemical Analysis, Vol. X.—*The Chemical Analysis of Air Pollutants*. By Morris B. Jacobs (Interscience Publishers, New York), 1960. Pp. xvii + 430. Price $ 13.50.

Introduction to Quantum Field Theory. By F. Mandl. (Interscience Publishers, New York), 1959. Pp. vii + 202. Price $ 6.00.

Chemical Analysis, Vol. XI.—*X-Ray Spectrochemical Analysis*. By L. S. Birks. (Interscience Publishers, New York), 1959. Pp. xii + 137. Price $ 5.75.

Genetical Research, Vol. 1, No. 1. Edited by E. C. R. Reeve. (Cambridge University Press, London N.W. 1), 1960. Pp. 172. Price 45 *sh*.

The Balkan Lake Ohrid and its Living World. By Sinisa Stankovic. (Dr. W. Junk Publishers, The Hague, Netherlands), 1960. Pp. 357. Price *f* 35.

Memoirs of the Society for Endocrinology, No. 7—*Sex Differentiation and Development*. Edited by C. R. Austin. (Cambridge University Press, London N.W. 1), 1960. Pp. x + 198. Price 45 *sh*.

Fast Neutron Physics, Part I. Edited by J. B. Marion and J. L. Fowler. (Interscience Publishers, New York-1), 1960. Pp. xiv + 983. Price $ 29.00.

Oxidation-Reduction Potentials of Organic Systems. By W. M. Clark. (The Williams and Wilkins Co., Baltimore-2, Maryland, U.S.A.), 1960. Pp. xi + 584. Price $ 13.30.

Symbolic Logic. By C. I. Lewis and C. H. Langford. (Dover Pub. Inc., New York-14, N.Y.), 1959. Pp. 518. Price $ 2.00.

SCIENCE NOTES AND NEWS

A Two-Parameter Discrete Approximation to any Unimodal Continuous Distribution with the Range (O,∞)

In obtaining approximate solution of the stationary distribution of the contents of a Dam, the method of employing a discrete approximation to a Unimodal continuous distribution with range 0 to ∞ is of particular advantage. In this connection, at the suggestion and guidance of Prof. K. Nagabhushanam, M. P. Sastry, Andhra University, Waltair, has been able to work out the general method of constructing a two-parameter discrete distribution as an approximation, which is an improvement on the one-parameter discrete distribution, mentioned previously by P. A. P. Moran.* The proposed distribution containing (essentially) two parameters is as follows:

$$p_n = n(\alpha + n\beta)\phi^n \qquad n = 0, 1, 2, \ldots\ldots$$

where α, β, ϕ are constants,

$$0 < \phi < 1, \quad \text{and} \quad \sum_{n=0}^{\infty} p_n = 1.$$

By putting suitable restrictions on the distribution, α and β are first expressed in terms of ϕ, which in turn is so chosen that the discrete distribution under consideration can be regarded as the 'best' approximation to the given Unimodal one.

It may however be remarked that the distribution proposed is not obtainable as a generalisation of the form of the distribution considered by Moran.

* *Aust. J. Appl. Sci.*, 1955, **6**, 117.

Occurrence of *Parasa lepida* Cram. (Lep. Limacodidae) on Arabica Coffee

S. Parthasarathy, H. T. Ranga Setty and B. Swaminathan of Coffee Research Substation, Chethalli, Coorg, write:—*Parasa lepida* Cram. is a polyphagous pest species feeding on Castor, Coconut, Ficus, Mango, etc. Possibility of Coffee, *Coffea arabica* Linn., serving as host for the species has also been suggested. (*Proc. II Ent. Meeting*, Pusa, 1917, p. 28).

In recent years, the incidence of this species on coffee has been noticed in varying degrees on many estates of North Coorg. The caterpillars were found feeding on tender arabica coffee leaves at the Coffee Research Substation, Chethalli, Coorg. This apparently is the first authentic record of the occurrence of this species on arabica coffee.

The young caterpillars are gregarious. The body possesses scoli and verruca-like structures bearing spines. Pupation takes place on stems in an oval, grey-coloured tough cocoon covered with spines and lasts about six weeks. The moths are medium-sized with conspicuous green shade on the forewings.

Control of this species has been successful through mechanical destruction of young caterpillars and cocoons. Application of Folidol E-605 at 4 oz. in 100 gallons of water has also been found to be effective against caterpillars.

Award of Research Degree

Andhra University has awarded the D.Sc. Degree in Technology to Shri R. Jagannadha Rao for his thesis entitled "Studies of Mass transfer in Perforated plate Extraction towers".

Utkal University has awarded the Ph.D. Degree in Botany to Shri Tapasa Kabi for his thesis entitled "Responses of Herbaceous dicot leaves to synthetic growth regulating substances".

Raptakos Medical Research Fellowships

The Raptakos Medical Research Board will consider applications for the award of Fellowships for research work on medical and allied subjects in recognized institutions situated in the Union of India. The awards normally consist of Rs. 3000 per year for a Fellowship and Rs. 750 per year towards contingencies approved by the Board.

Applications in the prescribed form, which may be obtained from the Secretary and Treasurer, should be forwarded through the Guides, under whom research work will be carried out, and the Heads of the Institutions. Each application should be accompanied by six copies of a brief statement of the research project and the comments of the Guide regarding the suitability of the project and the facilities existing at the Institution. Applicants should have an M.B., B.S. or M.Sc. degree or its equivalent or not less than two years' experience in research work after B.Sc. The awards are made annually and may be renewed on the basis of satisfactory progress.

Applications for grants for the year commencing January 1, 1961, should reach the Secretary and Treasurer, Raptakos Medical Research

Board, Dr. Annie Besant Road, Worli, Bombay-18, before September 30, 1960.

Lady Tata Memorial Trust—Scholarships and Grants for the Year 1960-61

The Trustees of the Lady Tata Memorial Trust announce on the death anniversary of Lady Meherbai Dorabji Tata, 18th June 1960, the awards of scholarships and grants for the year 1960-61.

International Awards of varying amounts (totalling £ 4,500) for research in diseases of the blood with special reference to Leucæmias are made to :

Dr. M. Simonsen (Denmark) ; Dr. J. Ponten (Sweden) ; Dr. (Miss) B. M. Braganca (India) ; Dr. J. Hastrup (Denmark) ; Dr. L. Chieco-Bianchi (Italy) ; Dr. H. J. Woodliff (Oxford).

Indian Scholarships of Rs. 250 per month each for one year for scientific investigations having a bearing on the alleviation of human suffering from disease are awarded to :

Miss M. D. Menon (Cochin) ; Miss M. Indira (Bangalore) ; Mr. V. S. Rao (Hyderabad) ; Mr. A. K. Ray (Calcutta) ; Dr. C. L. Sarin (New Delhi) ; Dr. P. S. Subba (New Delhi).

Citric Acid from Cotton

Messrs. D. J. Patel and I. P. Patel of Adarsh Chemicals and Fertilizers Ltd., of Navasari, W.R., report the recovery of citric acid from the leaves of the following cottons : Co 170 = about 6% ; Laxmi = about 2% ; Digvijay = about 1·5%.

Council of Scientific and Industrial Research, Chemical Research Committee

I. Symposium on "Proteins"

A two-day Symposium on Proteins will be held at Mysore during the first week of August 1960.

The scope of the Symposium will be as follows :

(1) Structures ; (2) Chemistry and Methodology ; (3) Biochemistry. (*a*) Biosynthesis ; (*b*) Metabolism and interrelationships, (*c*) Immunochemistry ; (4) Nutritive value ; (*a*) Amino-acid composition ; (*b*) Evaluation of protein quality ; (5) Technology : (*a*) Production of amino-acids, (*b*) Protein isolates, (*c*) Protein hydrolysates, (*d*) Protein-rich foods ; (6) Proteins in Human nutrition : (*a*) Prevention and treatment of Protein malnutrition, (*b*) Proteins in therapy ; (7) Industrial uses of proteins Adhesives, distempers, fibres, fillers, etc.

Workers in the field who wish to contribute papers and take part in the Symposium are requested to send their contributions along with abstracts (about 300 words) to Dr. A. Sreenivasan, Deputy Director, Central Food Technological Research Institute, Mysore.

It will be helpful if, as far as possible, each school of research reports the results relating to a particular subject of study in a single contribution.

II. Symposium on "Redox Processes"

A Symposium on Redox Processes will be held at the Chemical Laboratories, University of Allahabad, in the third week of January 1961.

Workers in the subject who wish to participate in the Symposium and to contribute papers for reading and discussion are requested that the titles of communications along with the names of the authors, may kindly be intimated by July 15, 1960. Abstracts (about 250 words), in duplicate, may kindly be sent by August 15, 1960. The full texts of the papers should be received by December 15, 1960. Communications to be addressed to Dr. Satya Prakash, Convener, Department of Chemistry, University of Allahabad, Allahabad.

Water Discharge of World Rivers

Dr. Mark Lvovich, the Soviet hydrologist, has compiled a new map of the discharge of the rivers of the world. According to the revised calculations the total discharge of all rivers is 36,560 cubic kilometres a year. 56% of this total is on account of the Atlantic slope (including the Arctic Ocean) and 44% on account of the Pacific slope (including the Indian Ocean). Over a third of the world total is discharged from the Asian continent.

The earth has an annual precipitation of 580,000 cubic kilometres, and thus the total annual river discharge is only a little more than 6% of the total precipitation.

Origin of the Blue Continuum in the Hydrogen Flame

A characteristic spectral feature of clean hydrogen flames is the continuum that gives them their natural, pale-blue appearance. The continuum extends approximately from 2200 Å to 6000 Å, and it is overlaid at the shorter wavelength region by the strong OH band system from about 3300 Å downwards. On the long wavelength side from about 6000 Å upwards there is present the system of vibration rotation bands of H_2O. The intermediate region, *ca* 3500-6000 Å shows a fairly flat maximum of intensity near 4500 Å and is free from any other interfering bands when fuel-rich flames are used.

In spite of much work on the hydrogen flame spectra, the origin of the blue continuum has not been well understood. Flame-photometric techniques recently developed by Sugden *et al.*, for the quantitative measurements of the concentrates of H and OH in hydrogen flame gases have enabled much light to be thrown on the nature of the fundamental flame reactions. A relevant result of such studies is that H and OH were found to be liberated in the reactive zone in concentrations that may be of the order of 1,000-fold in excess of the equilibrium values. These large quantities of H and OH were found to decay with time after leaving the reactive zone according to a second-order rate law. The two reactions predominantly responsible for this effect were shown to be

$$H + H + X \rightarrow H_2 + X$$
$$H + OH + X \rightarrow H_2O + X$$

where X is a third body H_2, N_2, or H_2O, predominantly H_2O.

These techniques applied to the problem of the blue continuum have yielded fruitful results. They strongly suggest that the origin of the continuum in clean hydrogen flames lies in the radiative recombination, $H + OH \rightarrow H_2O + h\nu$. —(*Trans. Farad. Soc.*, 1960, 56, 459).

Visual Pigment of the Horseshoe Crab, *Limulus polyphemus*

Thanks to the pioneering work of Hartline, the eye of the horseshoe crab, *Limulus*, has long been a classic object for electrophysiological investigation. This was the first eye in which electrical responses were recorded from single visual receptors. The large size of these units and the relative simplicity of their nervous connections have permitted a degree of analysis not achieved with other types of visual element. This growing body of electrophysiological information lends special interest to the chemistry of the underlying processes.

Wald and Hubbard have reported in a recent issue of *Nature* (1960, 186, 212), the results of their investigations on the visual pigment of *Limulus*. Incidentally, this is the fourth arthropod visual pigment to be examined and the first such pigment obtained from an arachnoid. The three earlier pigments studied were the two from crustaceans (a euphausiid, and a decapod, the lobster) and one from an insect, the honeybee.

Wald and Hubbard succeeded in obtaining a measurable quantity of the photosensitive pigment by first isolating the pigment-containing rhabdomere tissues from 378 eyes of young *Limulus*, by what is described as the flotation procedure, and then extracting the pigment by the usual chemical methods, and centrifuging. The extract contained β-carotene in good proportion. The absorption spectrum showed the wavelength maximum, $\lambda_{max.}$ 520 mμ, and the chromophore was found to be retinene$_1$. Thus the pigment could be identified as rhodopsin. On exposure to light it bleached to a mixture of retinene and opsin. This behaviour, characteristic of vertebrate rhodopsins, distinguishes the *Limulus* pigment sharply from certain other invertebrate rhodopsins—squid, octopus, cuttlefish, lobster—which under physiological conditions do not bleach but yield in the light relatively stable red-orange metarhodopsins, in which retinene remains attached as chromophore to opsin.

Further, calculation showed that the extinction of *Limulus* rhodopsin at 520 mμ was equivalent to an absorption of 15%. It is interesting that this absorption is of about the same order as occurs in the rods of a number of vertebrate eyes.

Observations on Atmospheric Radioactivity

Results of systematic study of the levels of atmospheric radioactivity at the Sutton (Surrey) Laboratory of the Institute of Cancer Research, Royal Cancer Hospital, London, have revealed a pronounced, but transitory, increase in activity during February 28 to March 1, 1960. The programme of study, started in May 1959, consisted in making radioactive measurements by β-counting and γ-activity on dust collected from the air by different methods.

The counting rate during the period of increased activity (February 28 to March 1) was about eight times the rate for the other days of the months.

The γ-scintillation spectra of the dust samples collected over the period of increased activity show prominent peaks which can be identified with those due to Lanthanum-140 and Zirconium-95. It is suggested that the sharp increase in the levels of radioactivity observed was due to the fission products of the first nuclear weapon test in the Sahara on February 13, 1960. It was, however, apparent that though detectable at the site of study, none of the nuclides was present at a level having biological significance.—*Nature*, 1960, 186, 223.

582-60. Printed at The Bangalore Press, Bangalore City, by T. K. Balakrishnan, Superintendent, and Published by A. V. Telang, M.A., for the Current Science Association, Bangalore.

All material intended for publication and books for review should be addressed to the Editor, *Current Science*, Raman Research Institute, Bangalore-6.

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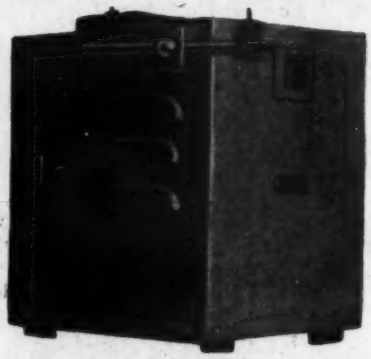

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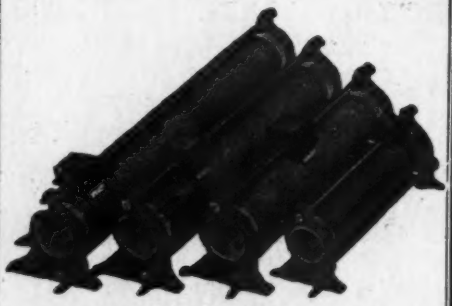

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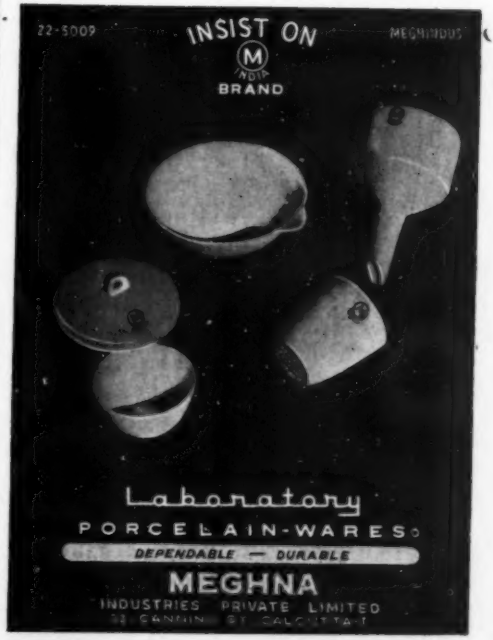

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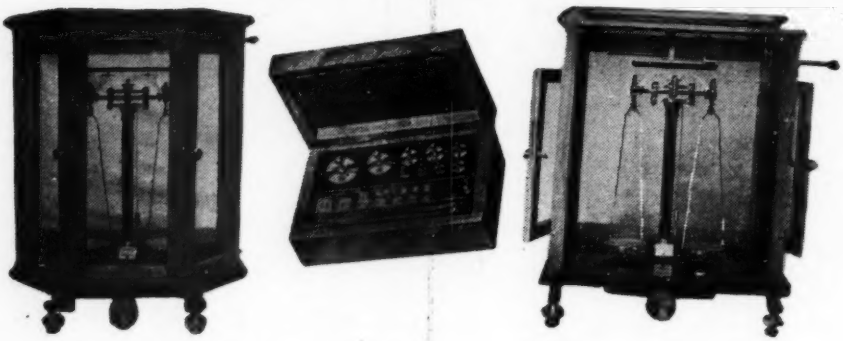

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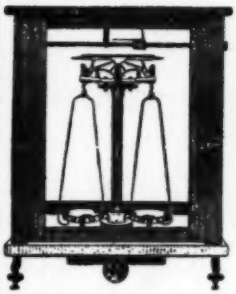

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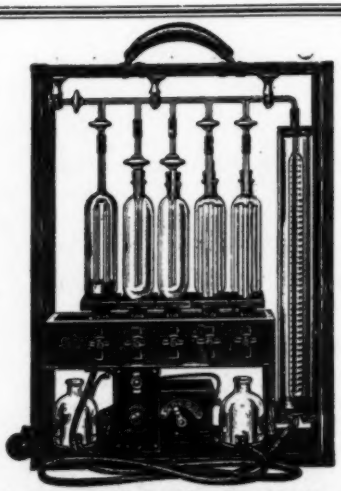

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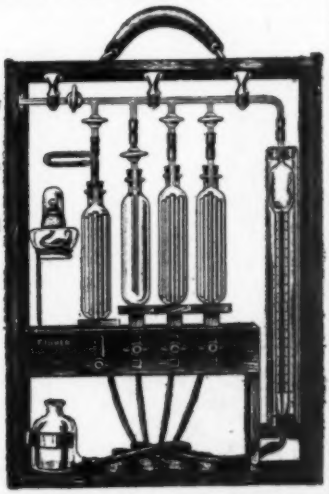

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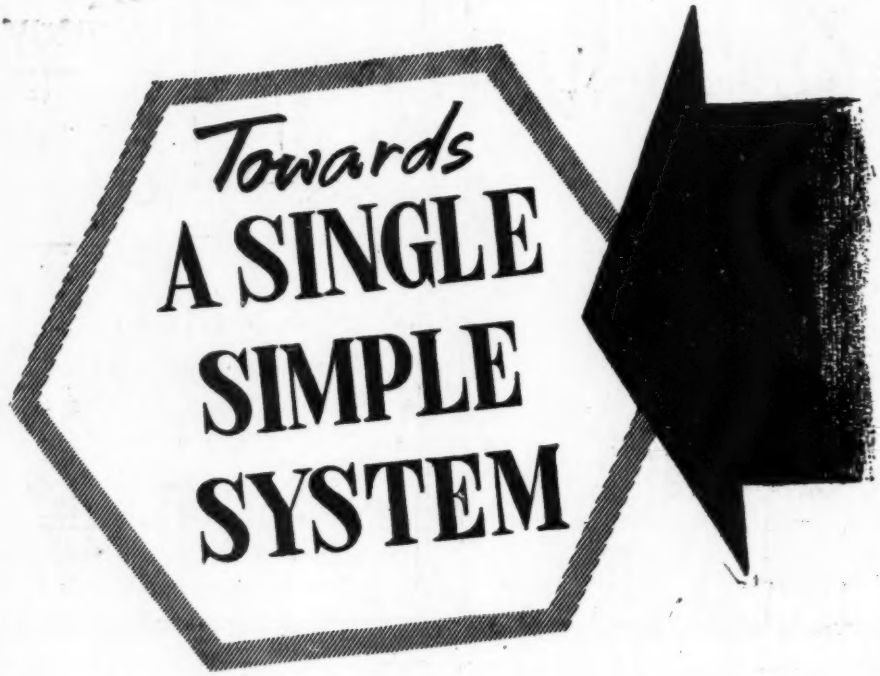
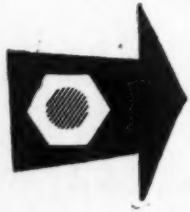


Another major step has been taken towards the goal of establishing a single, simple system of weights and measures in the country.

On October 1, 1958, Metric Weights were permitted in selected areas of the States and Union Territories. In these areas, only Metric Weights will be legal from October this year.

From April 1960, Metric Weights are allowed also in the rest of the country excepting Jammu and Kashmir.

Metric Weights will become compulsory throughout the country by April 1962.



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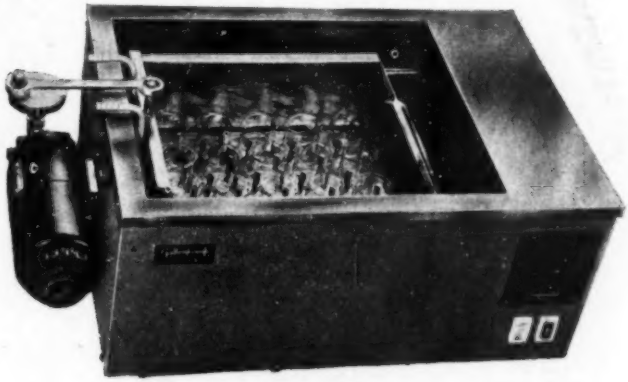

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* **Temperatures up to 100° C.**
* **Stainless steel construction.**
* **Speed range 50 to 200 oscillations/min.**
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* **Interchangeable sample racks.**
* **Provision for controlled atmosphere.**

WATER BATH

A stainless steel bath 14 × b12 × 6½″ deep, fitted with an external heater and slab insulation and mounted in a steel case finished in duotone grey stove enamel. Compenstat control (patent applied for) provides uniform conditions throughout the bath over the range ambient to 100° C.

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A motor, incorporating speed control and mains switch, is mounted on one end of the bath and drives the sample carrier through a crank assembly. The carrier is fitted with plastic wheels and runs on rails at each side of the bath. Interchangeable racks which fit in the carrier are available for the commonly used sample vessels. All components within the bath are of stainless steel and are easily removable

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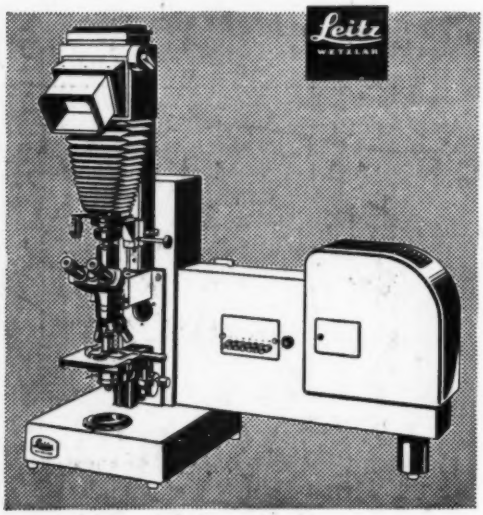

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